# Potential Natural Vegetation and Disturbance Regimes of the Eastern U.S. - A Lake States Example

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Research Liaison position description: "Work for (legally marry) research and management activities, and funding, to effectively assess ecological conditions including fire regimes, condition classes, and fire risk"

## Acknowledgements – Research Team

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# Potential Natural Vegetation and Disturbance Regimes of the Eastern U.S. - A Lake States Example

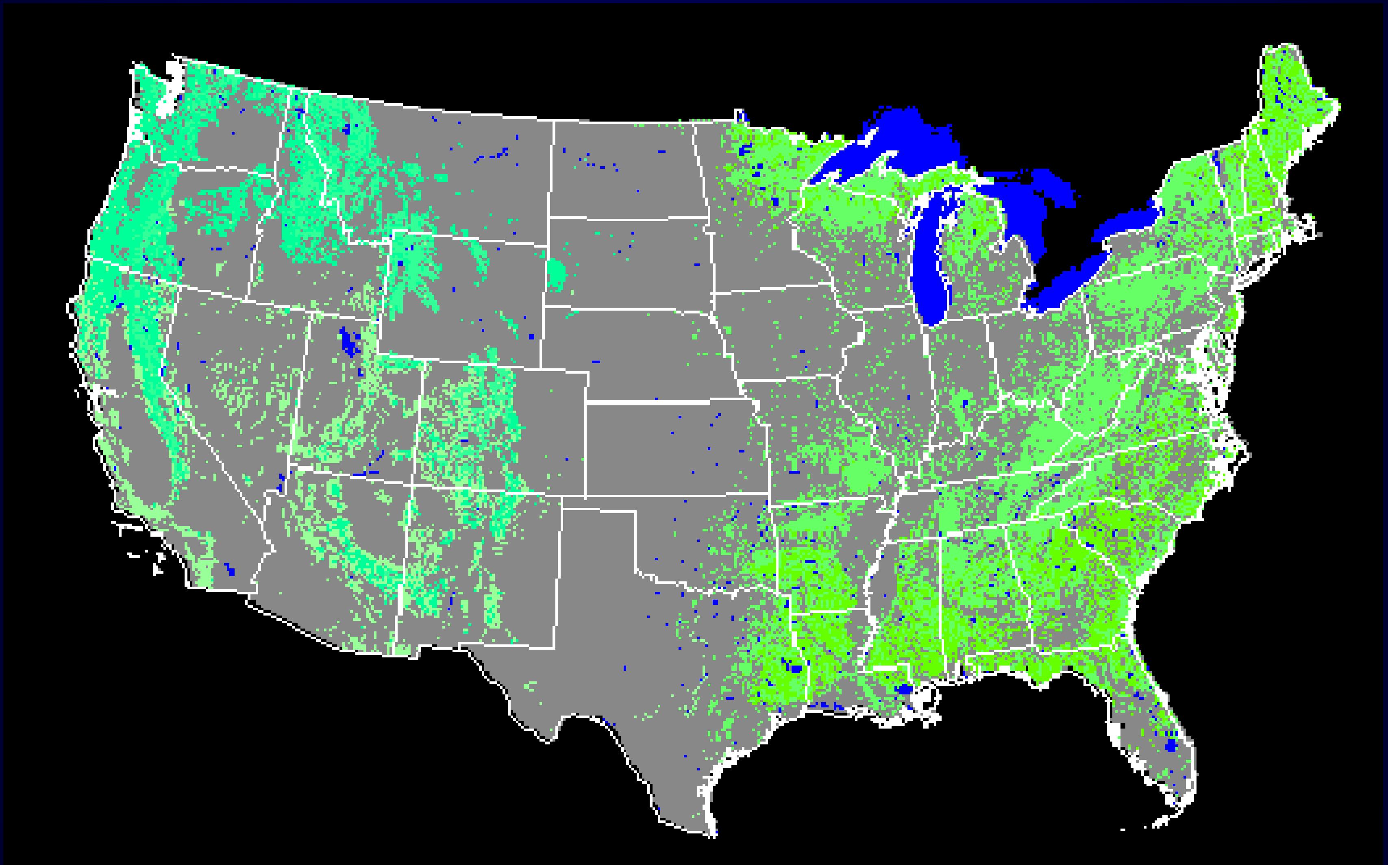
**"Potential natural vegetation (PNV)** is the plant community that would become established if all successional sequences were completed without human interference under the present environmental and floristic conditions, including those created by man. [Adapted from Tüxen (1956) as translated by Mueller-Dombois and Ellenberg (1974)]

Environmental conditions include climate, soil characteristics, and topography as well as natural disturbance processes such as drought, flooding, wildfire, insects, disease, and grazing by native fauna.**"**

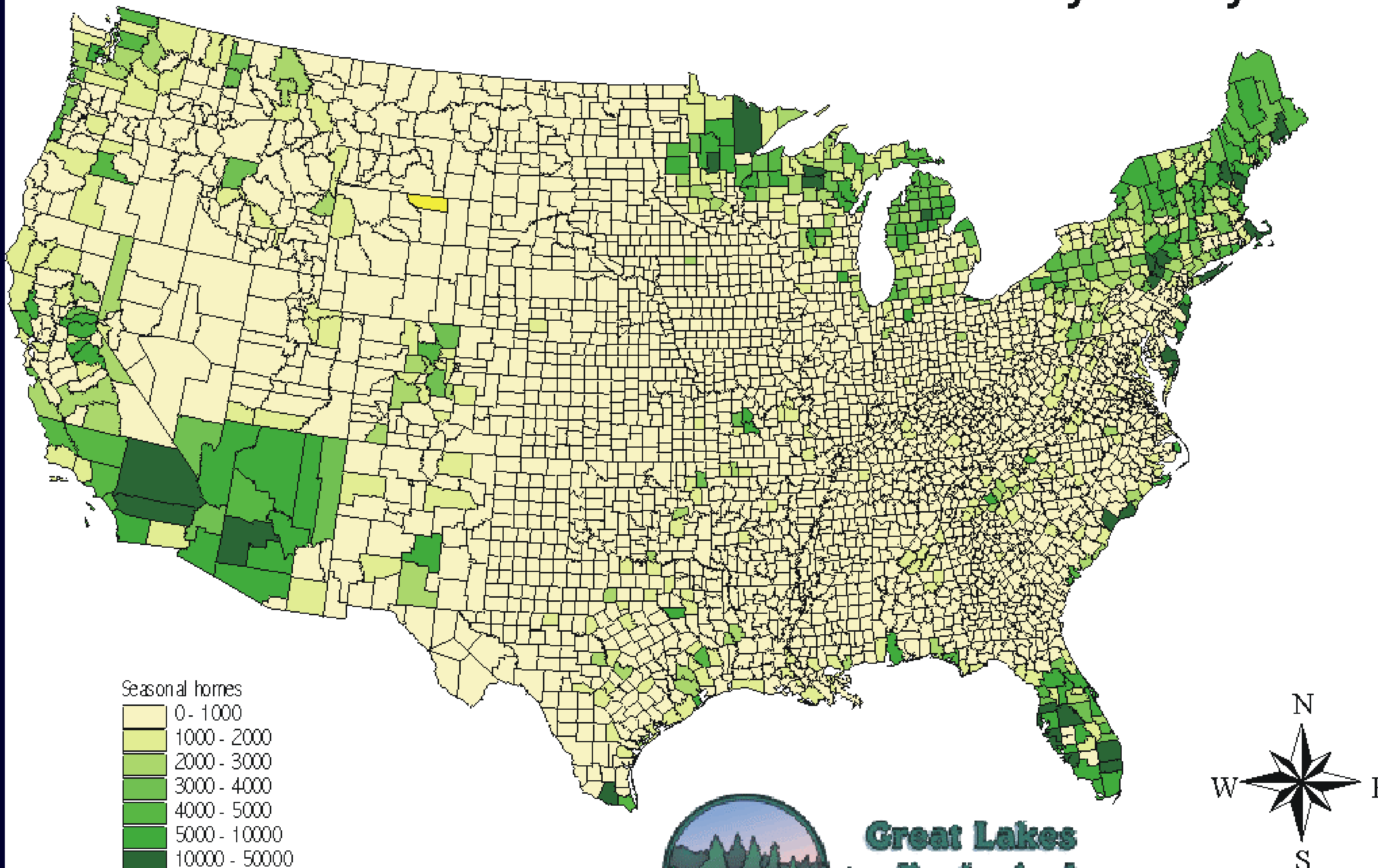
From: Terrestrial Ecological Unit Guide (in draft; Winthers, E., Fallon, D., Haglund, J., DeMeo, T., Tart, D., Ferwerda, M., Robertson,G., Gallegos, A., Rorick, A., and Shadis,D. 2002.) USDA Forest Service, Washington Office – Ecosystem Management Coordination Staff, Technical Guide xx, 125 pp.

# Background – Lake States

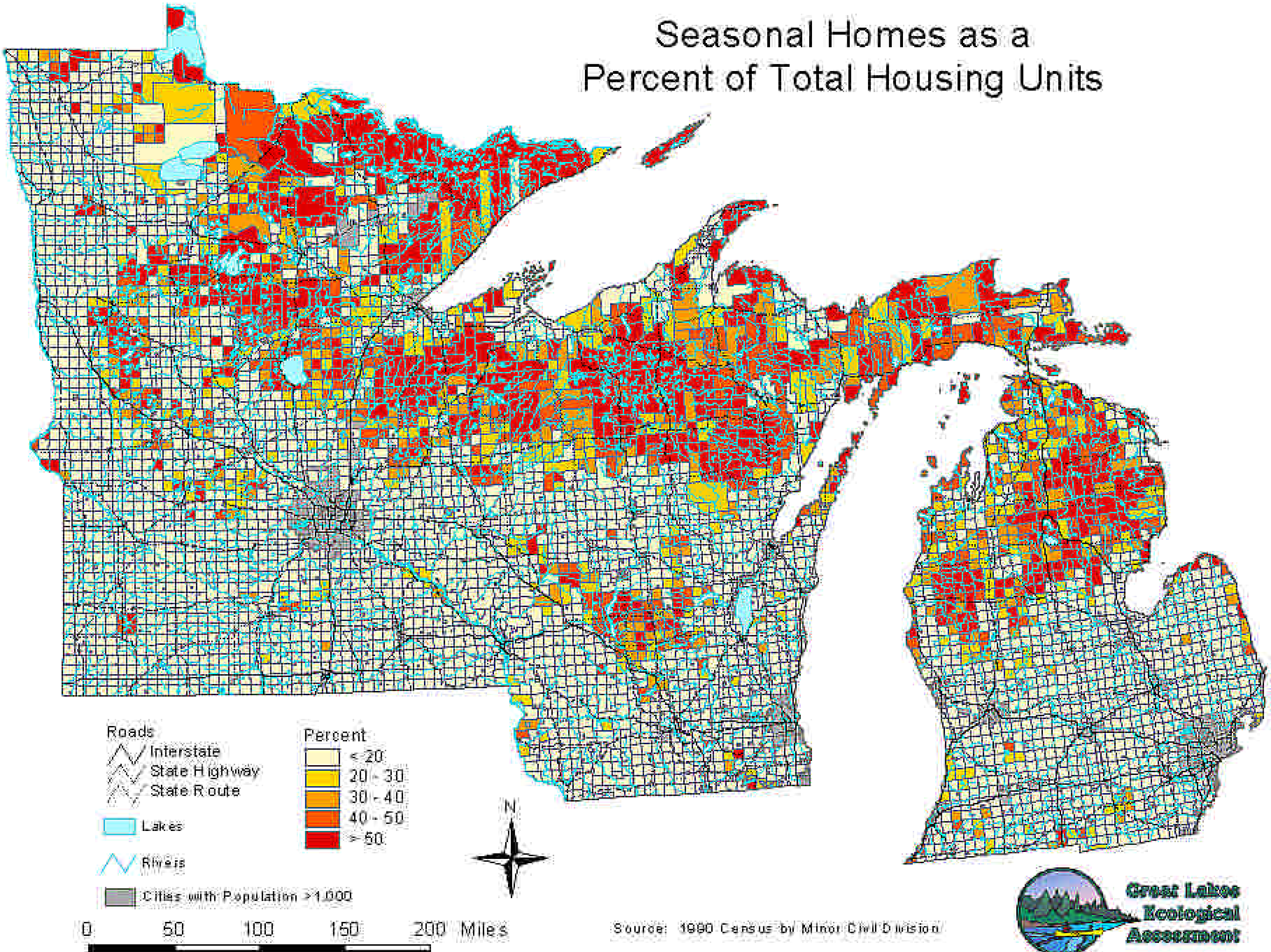
The northern Lake States comprise one of the most densely forested regions of the nation, with 41% of the total area or 51.9 million acres in forested lands.  About 52% of this forestland is owned by the nonindustrial private sector.



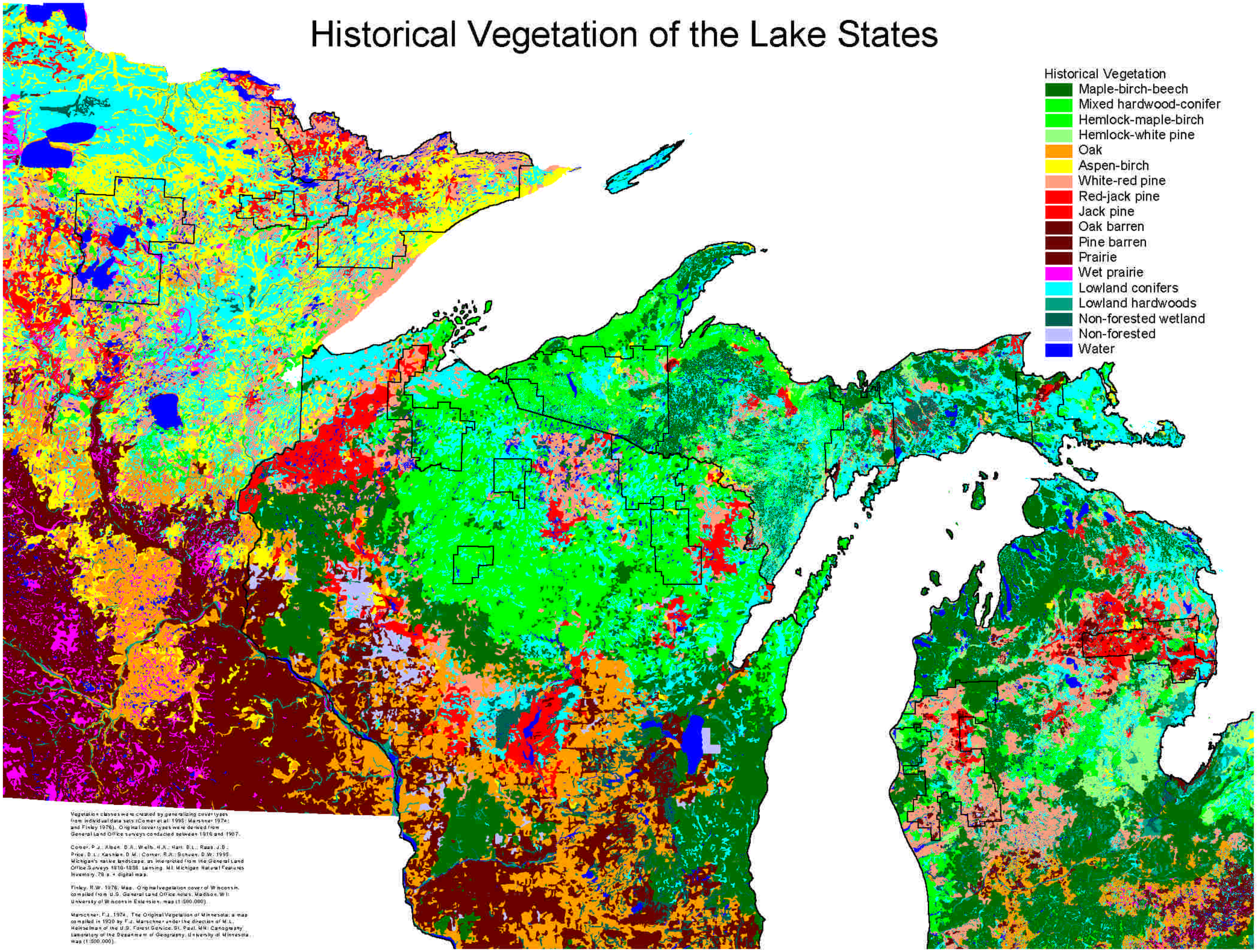
# Number of seasonal homes by county




Great Lakes Ecological Assessment


Seasonal Homes as a
Percent of Total Housing Units
Roads
Interstate
State Highway
State Route
Lakes
Rivers
Cities with Population > 1,000
Percent
< 20
20 - 30
30 - 40
40 - 50
> 50
N
0 50 100 150 200 Miles
Source: 1990 Census by Minor Civil Division
Great Lakes Ecological Assessment

# History of the Lake States Affecting Potential versus Modern Vegetation




Vegetation classes were created by generalizing cover types from individual data sets (Comer et al. 1995; Marshner 1974; and Finley 1976). Original cover types were derived from General Land Office surveys conducted between 1816 and 1907.

Comer, P.J., Albert, D.A., Wells, H.A., Hart, B.L., Raab, J.B., Price, D.L., Kashian, D.M., Corner, R.A., Schuen, D.W. 1995. Michigan's native landscape, as interpreted from the General Land Office Surveys 1816-1856. Lansing, MI: Michigan Natural Features Inventory. 78 p. + digital map.

Finley, R.W. 1976. Map. Original vegetation cover of Wisconsin, compiled from U.S. General Land Office notes. Madison, WI: University of Wisconsin Extension. map (1:500,000).

Marschner, F.J. 1974. The Original Vegetation of Minnesota: a map compiled in 1930 by F.J. Marschner under the direction of M.L. Heinselman of the U.S. Forest Service. St. Paul, MN: Cartography Laboratory of the Department of Geography, University of Minnesota. map (1:500,000).

White and red pine ecosystems were maintained by frequent low intensity surface fires that reduced fuels and caused wide tree spacing, and less frequent catastrophic fires.

Pine barrens, oak savannas, and prairies were maintained by very frequent surface fires.

# Historical Context of the Lake States Affecting Potential and Current Vegetation

The white pine logging began about 1836 and reached a peak between 1890 and 1910, by which time virtually all merchantable pine had been either cut or destroyed by fire.

During the white pine era, hemlock was cut heavily as a source of tannin for processing cow hides into leather, resulting in the extirpation of this species in much of today's forests.

# Historical Context of the Lake States Affecting Potential and Current Vegetation

In the mid-1890’s harvesting of hardwoods commenced, continuing into the 1930's, by which time 98% of the Lake States had been clearcut.

The impact of near-total deforestation was amplified by frequent and often catastrophic wildfires burning through slash, as well as smaller fires that were deliberately set to clear land, or started from railroad locomotives.

While supporting the explosive growth of the Midwest, the turn-of-the-century logging era represented a wasteful exploitation of the region’s forests.

# Historical Context

Due to this history:

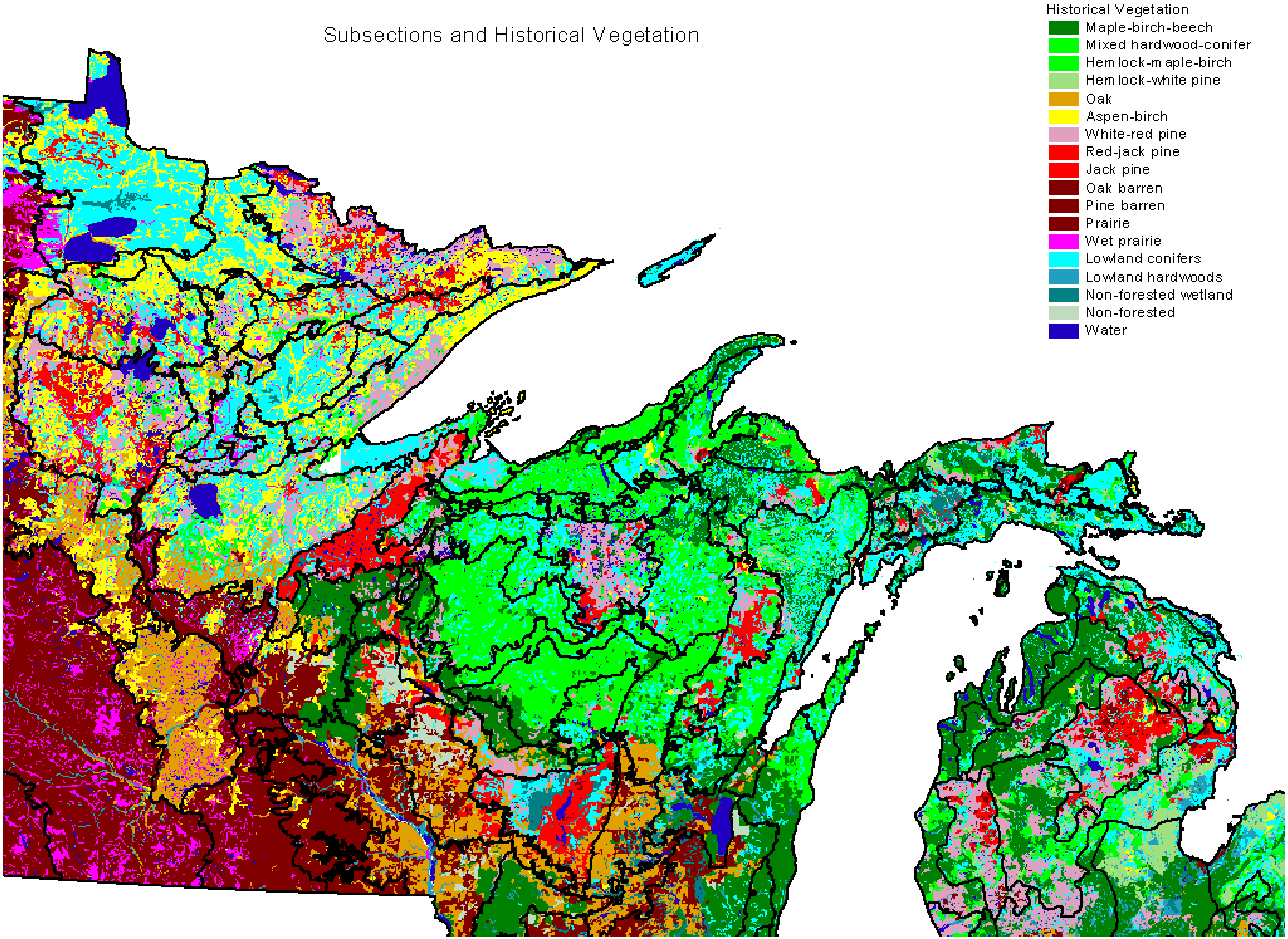
Millions of acres formerly composed of flammable conifer species were converted to deciduous forest communities, principally aspen, oak, red maple, and paper birch.

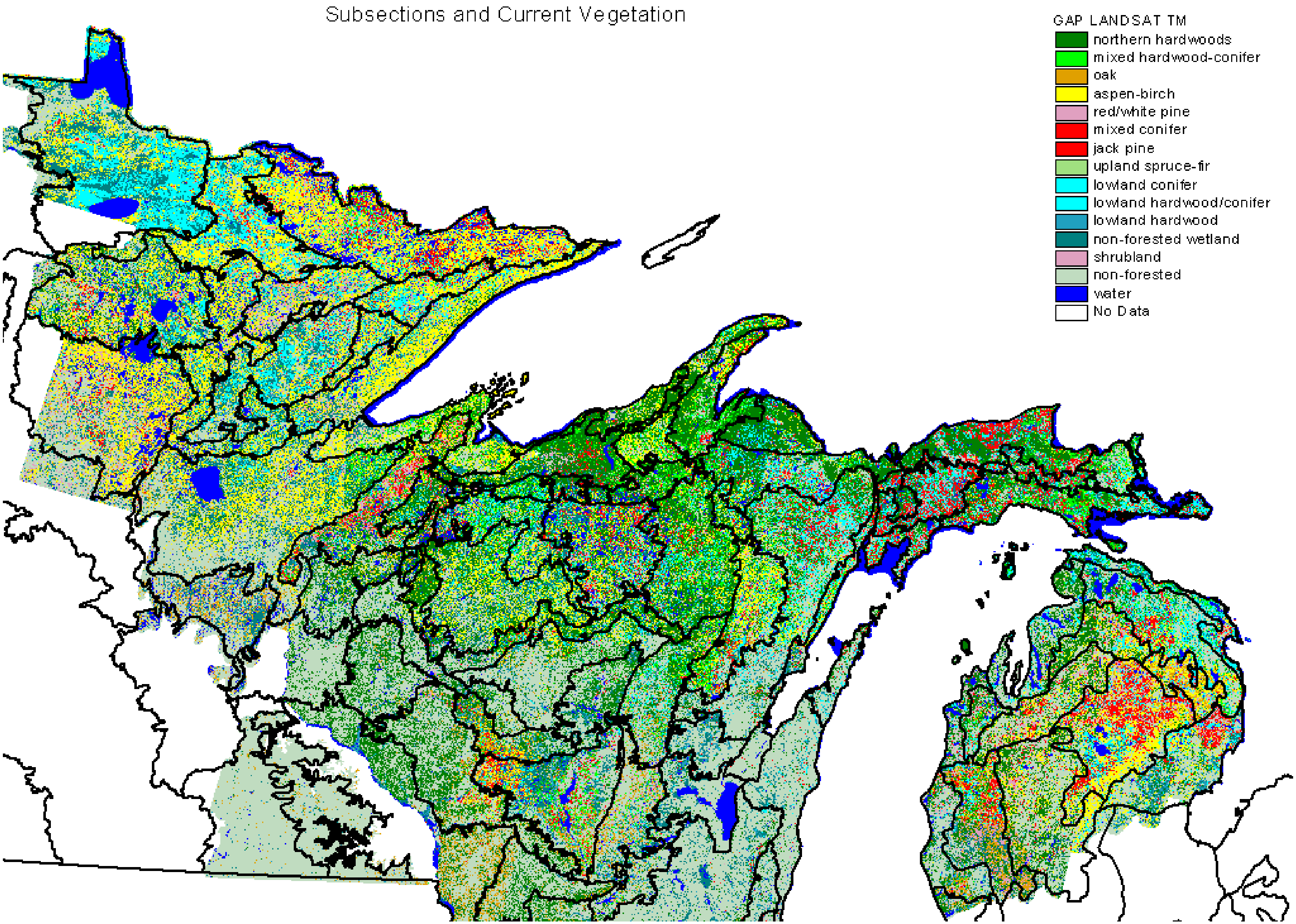
Landscape ecosystems too xeric to support these deciduous communities, or those repeatedly burned, remained unforested due to the absence of seed sources (the adult pine were harvested or burned).

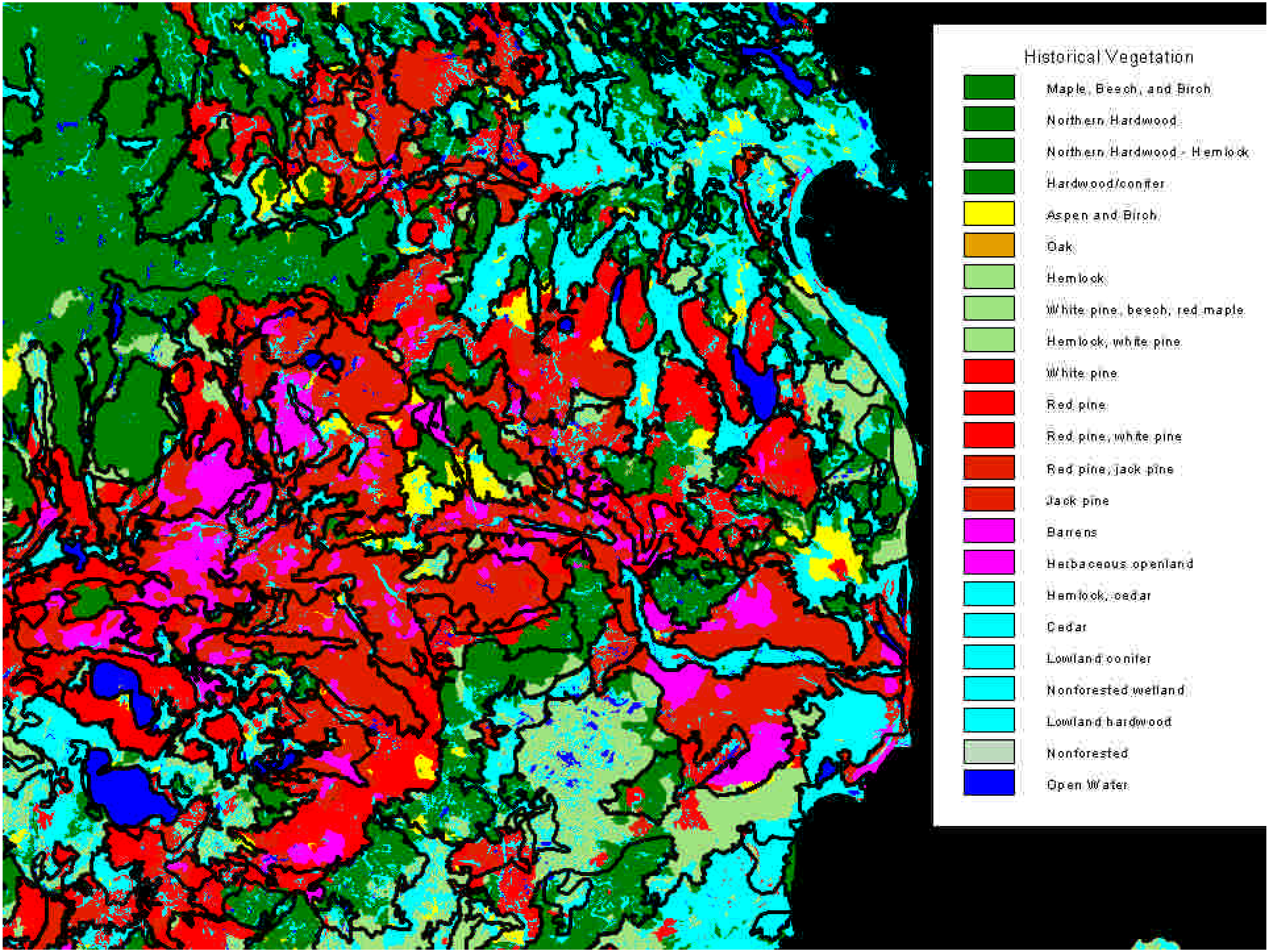
Abandoned farms established on infertile sands also lay idle.

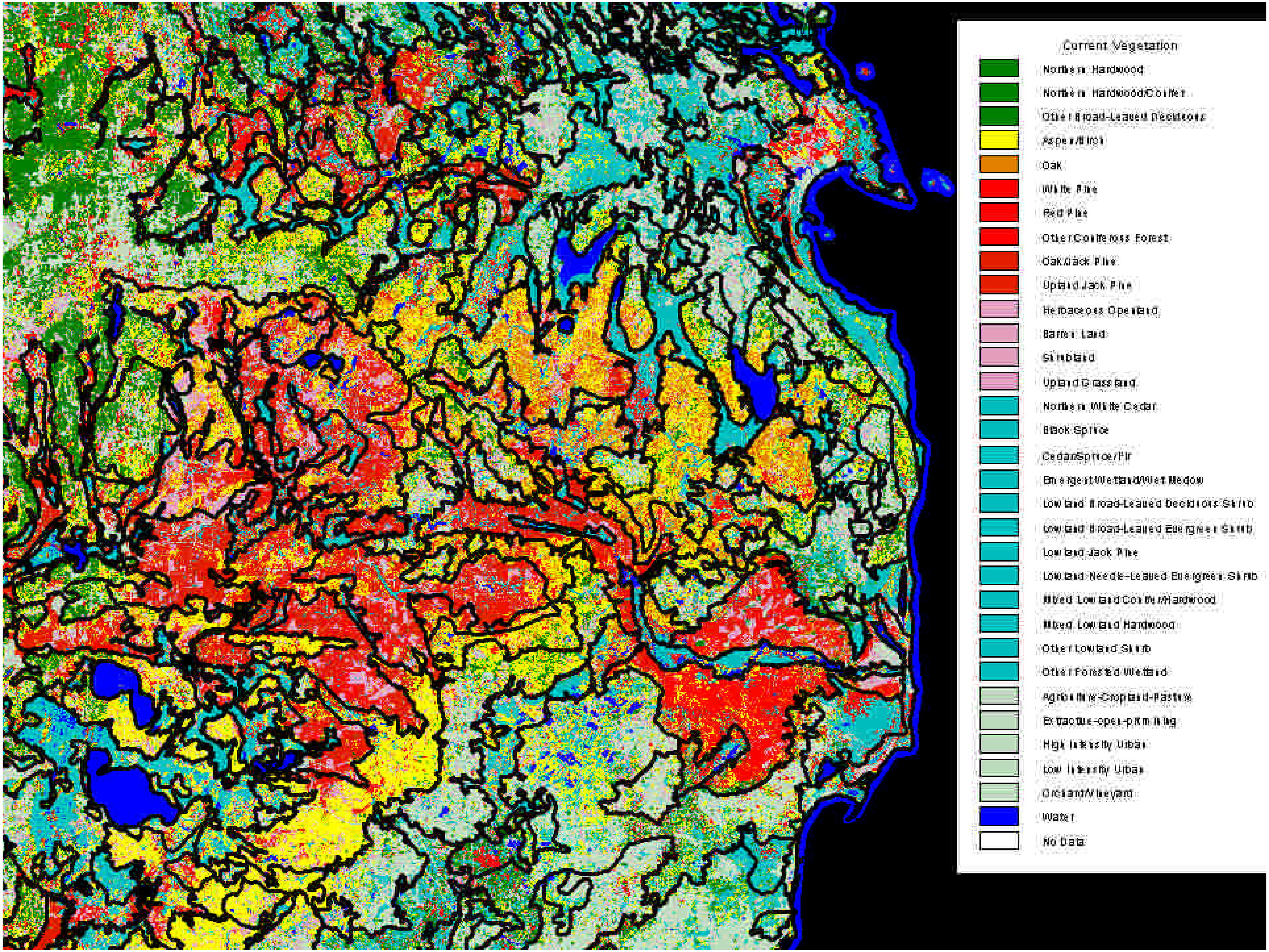
Many of these landscape ecosystems were replanted during the 1930's by the Civilian Conservation Service, often times to the original fire-prone jack or red pine forests.

Subsections and Historical Vegetation




Subsections and Current Vegetation
GAP LANDSAT TM
northern hardwoods
mixed hardwood-conifer
oak
aspen-birch
red/white pine
mixed conifer
jack pine
upland spruce-fir
lowland conifer
lowland hardwood/conifer
lowland hardwood
non-forested wetland
shrubland
non-forested
water
No Data


Historical Vegetation
Maple, Beech, and Birch
Northern Hardwood
Northern Hardwood - Hemlock
Hardwood/conifer
Aspen and Birch
Oak
Hemlock
White pine, beech, red maple
Hemlock, white pine
White pine
Red pine
Red pine, white pine
Red pine, jack pine
Jack pine
Barrens
Herbaceous openland
Hemlock, cedar
Cedar
Lowland conifer
Nonforested wetland
Lowland hardwood
Nonforested
Open Water


Current Vegetation
Northern Hardwood
Northern Hardwood/Conifer
Other Broad-Leaved Deciduous
Aspen/Birch
Oak
White Pine
Red Pine
Other Coniferous Forest
Oak/Jack Pine
Upland Jack Pine
Herbaceous Openland
Barren Land
Shrubland
Upland Grassland
Northern White Cedar
Black Spruce
Cedar/Spruce/Fir
Emergent Wetland/Wet Medow
Lowland Broad-Leaved Deciduous Shrub
Lowland Broad-Leaved Evergreen Shrub
Lowland Jack Pine
Lowland Needle-Leaved Evergreen Shrub
Mixed Lowland Conifer/Hardwood
Mixed Lowland Hardwood
Other Lowland Shrub
Other Forested Wetland
Agriculture-Cropland-Pasture
Extractive-open-pit mining
High Intensity Urban
Low Intensity Urban
Orchard/Vineyard
Water
No Data

Today's conifers represent a severe crown-fire risk, and converted aspen-oak systems represent a significant surface fire risk due to recalcitrant fuels (litter) along the forest floor and succession back to the original conifer forest in the understory.

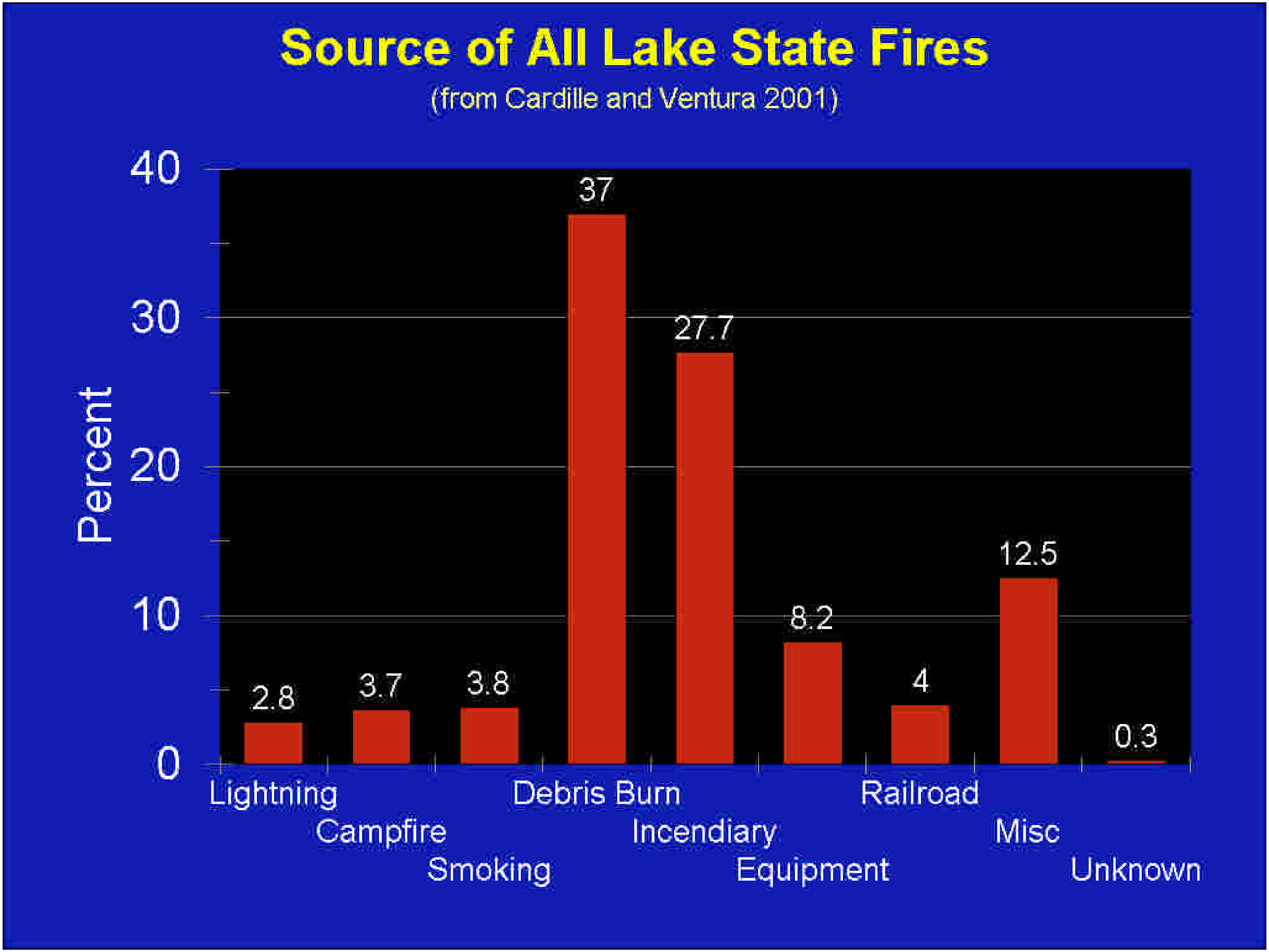
Coupled with the unique wildland – intermix conditions of the Lake States, fire risk and consequence is serious within fire-prone landscape ecosystems

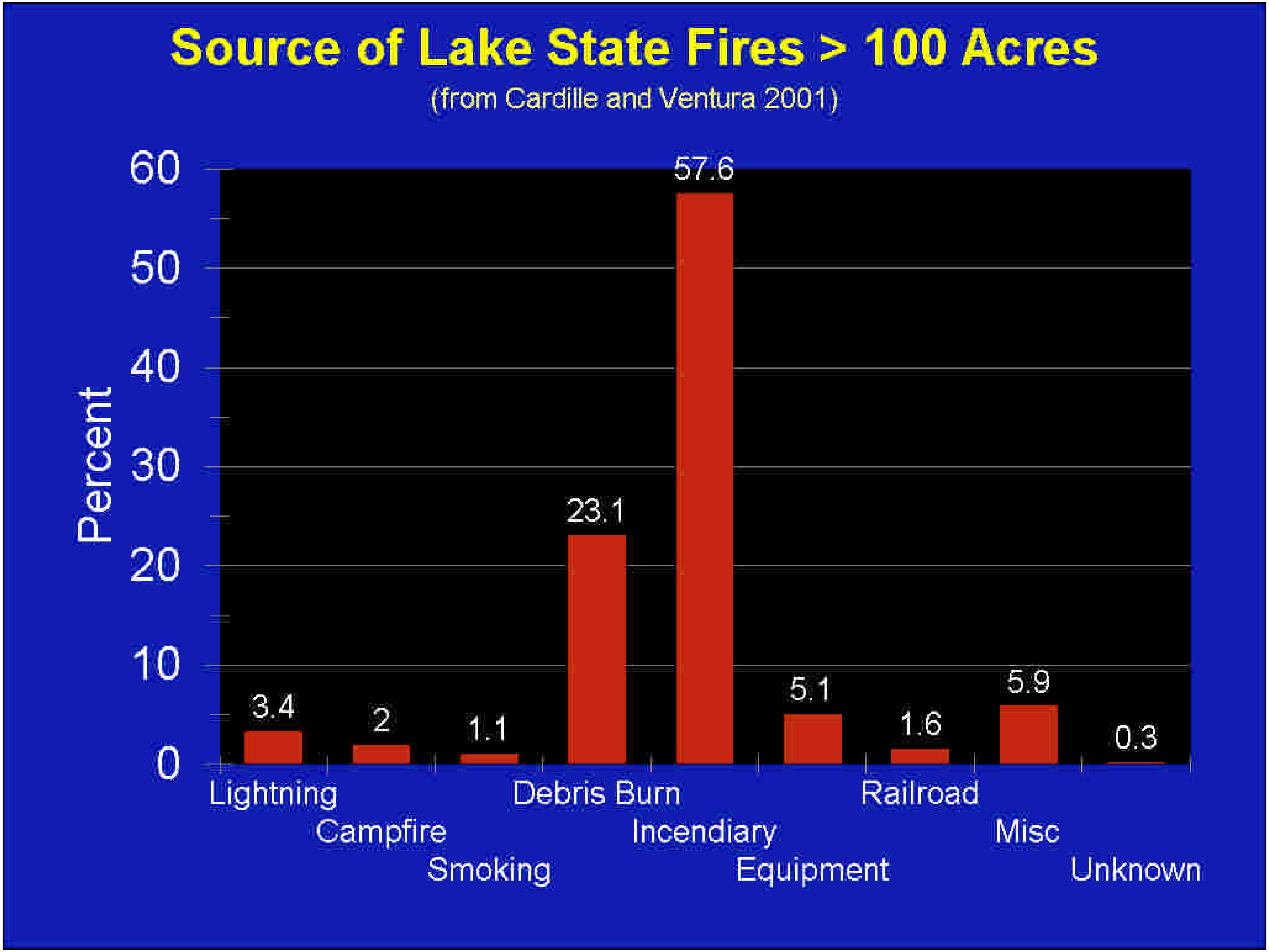
# Why Study Historical (1800's) Fires?

Fire regimes are inherently difficult to assess because the high variance associated with any low-probability event requires a large sample size to determine expected values

Only 2% of the 65,000 modern Lake States fires that occurred between 1985 and 2000 are >100 acres, and 0.18% >1000 acres.

As a consequence, while the potential for large fires exists in certain landscape ecosystems, the sample size for large fires is too small to develop predictive equations of the likelihood of catastrophic fires.


Source of All Lake State Fires
(from Cardille and Ventura 2001)
Percent
40
30
20
10
0
37
27.7
8.2
2.8
3.7
3.8
4
12.5
0.3
Lightning
Campfire
Smoking
Debris Burn
Incendiary
Equipment
Railroad
Misc
Unknown


Source of Lake State Fires > 100 Acres
(from Cardille and Ventura 2001)
Percent
60
50
40
30
20
10
0
3.4
2
1.1
23.1
57.6
5.1
1.6
5.9
0.3
Lightning
Campfire
Smoking
Debris Burn
Incendiary
Equipment
Railroad
Misc
Unknown

# Why Study Historical (1800's) Fires?

The latent structure within the Lake State's modern fire database largely reflects human ignition, detection, and suppression, not the arrangement and flammability of fuels governing the potential of fire spread.

While the modern fire database is useful for understanding interactions of human and ecological factors affecting fire regimes, it is insufficient for quantifying the potential of catastrophic fire when analyzed alone.

# Why Study Historical (1800's) Fires?

Historical fires represent pre-suppression fire behavior useful for understanding fire regimes associated with different types of landscape ecosystems.

Comparisons of historical and modern fire regimes provide an indication of the effectiveness of current fire suppression.

When used in conjunction with information on the distribution and flammability of existing fuels, historical fire regimes characterized within analogous landscape ecosystems (LTA's and LT's) are useful for identifying areas where fuel treatments are most needed.

# Landscape Ecosystems and Disturbance Regimes

Fire regimes depend upon the frequency and seasonality of ignition, and factors influencing fire spread including:

- landscape-scale patterns in fuels, fuel breaks, and topography
- local-scale arrangement and flammability of fuels, and

Geologic and topographic variations, and subsequent soil patterns, strongly influence:

- fire movement, and
- the distribution of fire-prone or fire-resistant communities

# Landscape Ecosystems and Disturbance Regimes

Since the inception of the discipline, fire scientists have recognized that interactions of climate, soils, topography, and vegetation affect fire occurrence (Plummer 1912, Mitchell and Sayre 1929, Mitchell and LeMay 1952).

Numerous studies conducted over the past century within or near the Lake States support the premise that there are strong relationships between fire regimes, forest type, and topography, landforms, soils, and hydrography.

(28 references: Strong 1877, Harvey 1922, Waterman 1922, Corson et al. 1929, Kittredge and Chittenden 1929, Stallard 1929, Gates 1930, Davis 1935, Kell 1938, McComb and Loomis 1944, Spurr 1956, McAndrews 1966, Nordin and Grigal 1976, Davis 1977, Cwynar 1978, Swain 1980, 1981, Wright 1981, Host et al. 1987, Bergeron and Brisson 1990, Nowacki et al. 1990, Abrams 1992, Frelich 1992, Dansereau and Bergeron 1993, Barrett 1995, He and Mladenoff 1999, Radeloff 2000, Zhang et al. 2000).

# Landscape Ecosystems and Disturbance Regimes

Thus mapping systems accounting for the spatial variability of these ecological factors should be useful in assessing fire regimes and fire risk.

Landtype Associations (LTA's) in the Lake States were mapped based upon naturally occurring associations among landforms, soil, hydrography, and vegetation.

Broader-scale ecological units (Sections and Subsections) are being used for assessing effects of climatic gradients, inter-annual variations in weather, and gross patterns in physiography on fire regimes.

# Landscape Ecosystems and Disturbance Regimes

Moreover, the three principal measures of fire regimes, fire rotations, fire frequency, and fire return intervals require clearly specifying the location and size of the area of interest.

**Fire cycle**—Length of time necessary for an area equal to the entire area of interest (i.e. the study area) to burn (syn. fire rotation). Size of the area of interest must be clearly specified.

**Fire occurrence**—Number of fires per unit time in a specified area (syn. fire frequency). The reciprocal of mean fire interval.

**Fire interval**—Time in years between two successive fires in a designated area; i.e. the interval between two successive fire occurrences (syn. fire-free interval).

**Mean fire interval**—Arithmetic average of all fire intervals determined, in years, in a designated area during a specified time period; size of the area and the time period must be specified (syn. mean fire-free interval).

# Landscape Ecosystems and Disturbance Regimes

Large areas experience more fires, and have shorter fire return intervals than smaller areas.

Heterogeneous areas inevitably contain many plant communities, so estimates of fire rotation, frequency or return intervals for such areas represent an amalgamation of several fire regimes.

Analysis of heterogeneous areas dilutes the relevance of estimates for condition class mapping, fire regime characterization, or fire risk assessment.

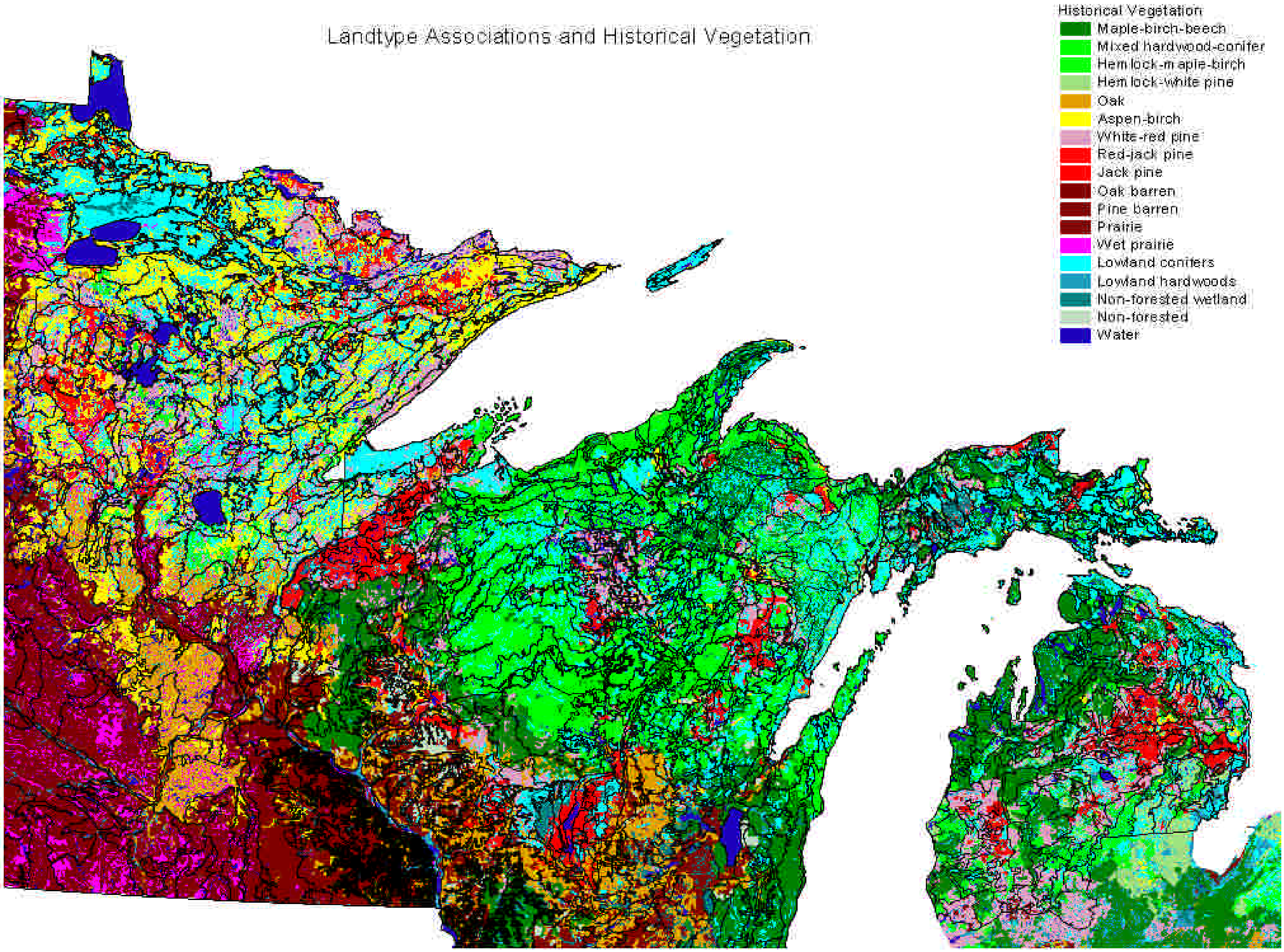
## Landscape Ecosystems and Disturbance Regimes

**Key Point:**

Reducing the spatial variability of factors affecting fire regimes by identifying ecologically homogenous areas within which fire rotations, frequencies, and return intervals can be analyzed is an essential step in the assessment of natural disturbance regimes and fire risk.

# Three distinct landscape ecosystems – LTA's

# Landtype Associations and Historical Vegetation



## Landscape Ecosystem Forest Replacement (FR) Fire Regimes Classes

FR1 – landscape ecosystems historically experiencing very frequent, large catastrophic stand-replacing fires.
- These ecosystems typically occur within very dry, flat outwash plains underlain by coarse-textured sandy soils.
- The dominant forest types were short-lived jack pine forests, mixed jack-red pine forests, and barrens and savannas.

FR2 – landscape ecosystems historically experiencing frequent, large catastrophic stand-replacing fires.
- These ecosystems typically occur within dry outwash plains and ice-contact landforms underlain by sandy and loamy sand soils.
- The dominant forest types were white-red pine and mixed red-white-jack pine forests.

## Landscape Ecosystem Forest Replacement (FR) Fire Regimes Classes

FR3 – landscape ecosystems historically experiencing relatively infrequent stand-replacing fires.
- These ecosystems typically occur within ice-contact and glacial lakebed landforms underlain by loamy sand to silt loam soils.
- The dominant forest type was long-lived mixed hemlock-white pine forests with minor elements of northern hardwood forests.

FR3W – landscape ecosystems historically experiencing relatively frequent stand-replacing or community maintenance fires.
- These ecosystems typically occur within poorly and very poorly drained wetlands embedded within or adjacent to fire-prone landscapes (i.e., landscape context).
- The dominant forest types were wetland conifers including tamarack, spruce, hemlock, and cedar.

## Landscape Ecosystem Forest Replacement (FR) Fire Regimes Classes

FR4 – landscape ecosystems historically experiencing very infrequent stand-replacing or community maintenance fires.

- These ecosystems typically occur within mesic (moist) moraines underlain by fine-textured loamy to heavy clay loam soils.
- The dominant forest types were fire-resistant northern hardwood and hardwood-hemlock forests
- Historical fires were often associated with large-scale severe wind events.

FR4W – landscape ecosystems historically experiencing very infrequent stand-replacing or community maintenance fires.

- These ecosystems typically occur within wetlands embedded within or adjacent to fire-resistant landscape ecosystems (FR4).
- The dominant forest types were wetland hardwood-conifer forests including cedar, hemlock, black and green ash, silver maple, and elm.

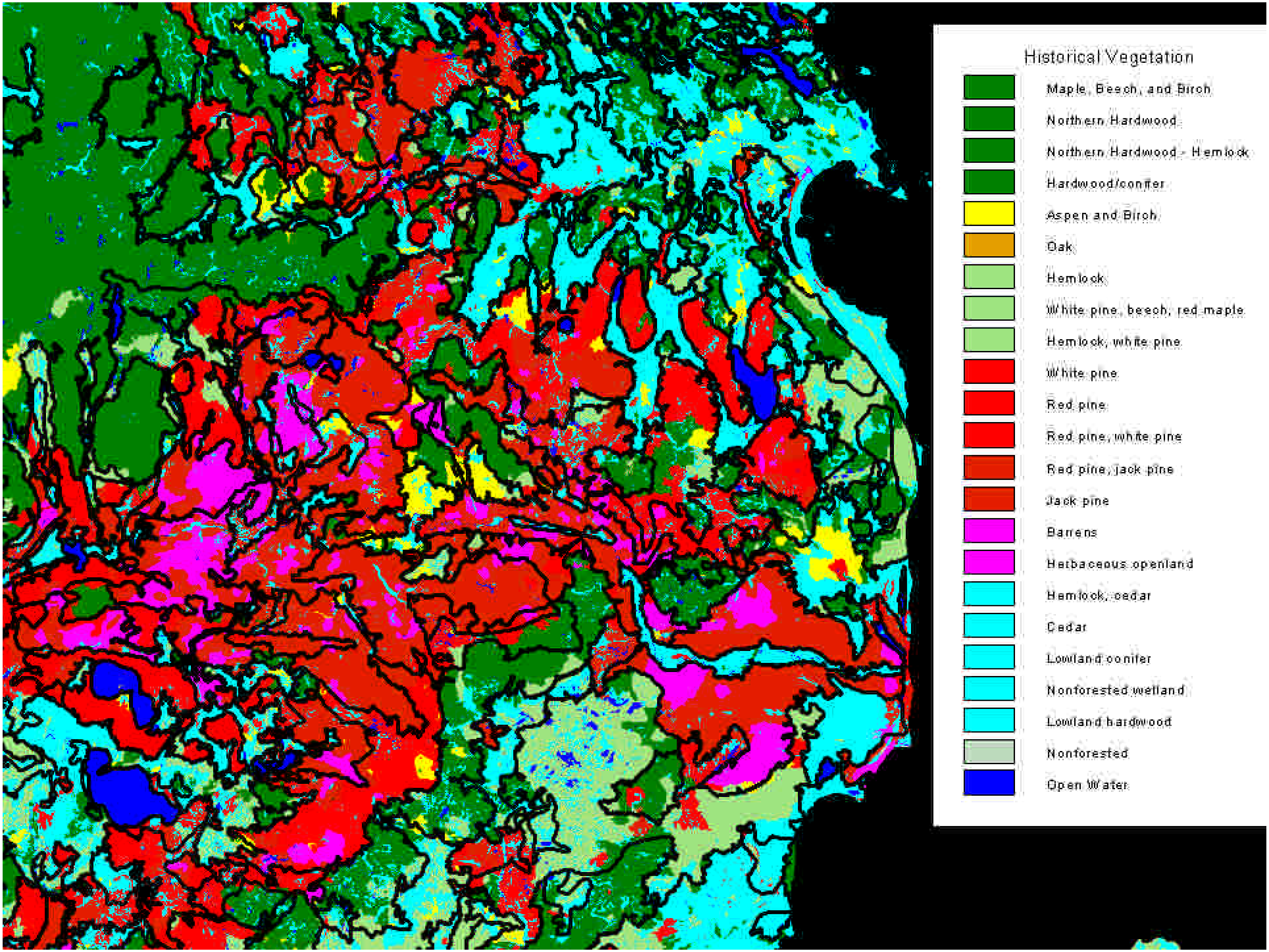
# LAKE STATES HISTORICAL FIRE REGIME CATEGORIES GLEANED FROM THE LITERATURE

| | FUNCTION | INTENSITY | ROTATION |
|---|---|---|---|
| FR1 | FOREST REPLACEMENT | HIGH | 50-75 YRS. |
| FR2 | FOREST REPLACEMENT | HIGH | 75-150 YRS. |
| FR3 | FOREST REPLACEMENT | HIGH | 150-350 YRS. |
| FR3W | FOREST REPLACEMENT | HIGH | Undocumented |
| FR4 | FOREST REPLACEMENT | MODERATE | 350-1000YRS. |
| FR4W | FOREST REPLACEMENT | MODERATE | >3000YRS |
| CM | COMMUNITY MAINTENANCE | MODERATE | 3-30 YRS. |
| SM | SAVANNA MAINTENANCE | LOW | 5-15 YRS. |
| FM1 | FOREST MAINTENANCE | LOW | 5-50 YRS. |
| FM2 | FOREST MAINTENANCE | LOW | 25-100 YRS. |

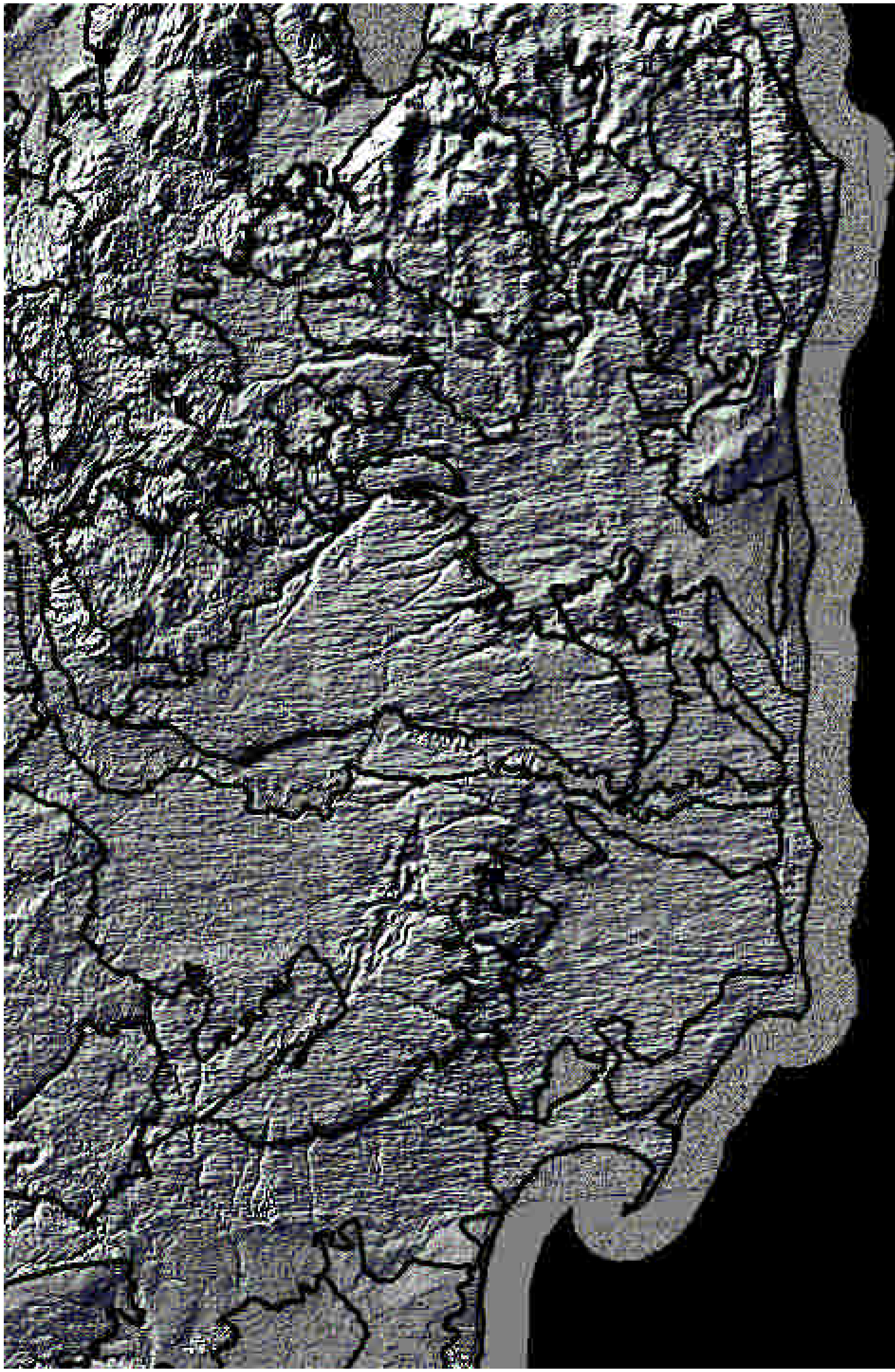
# Natural disturbance regimes maps are being produced through analysis and synthesis of georelational and plot-level databases

**These include**

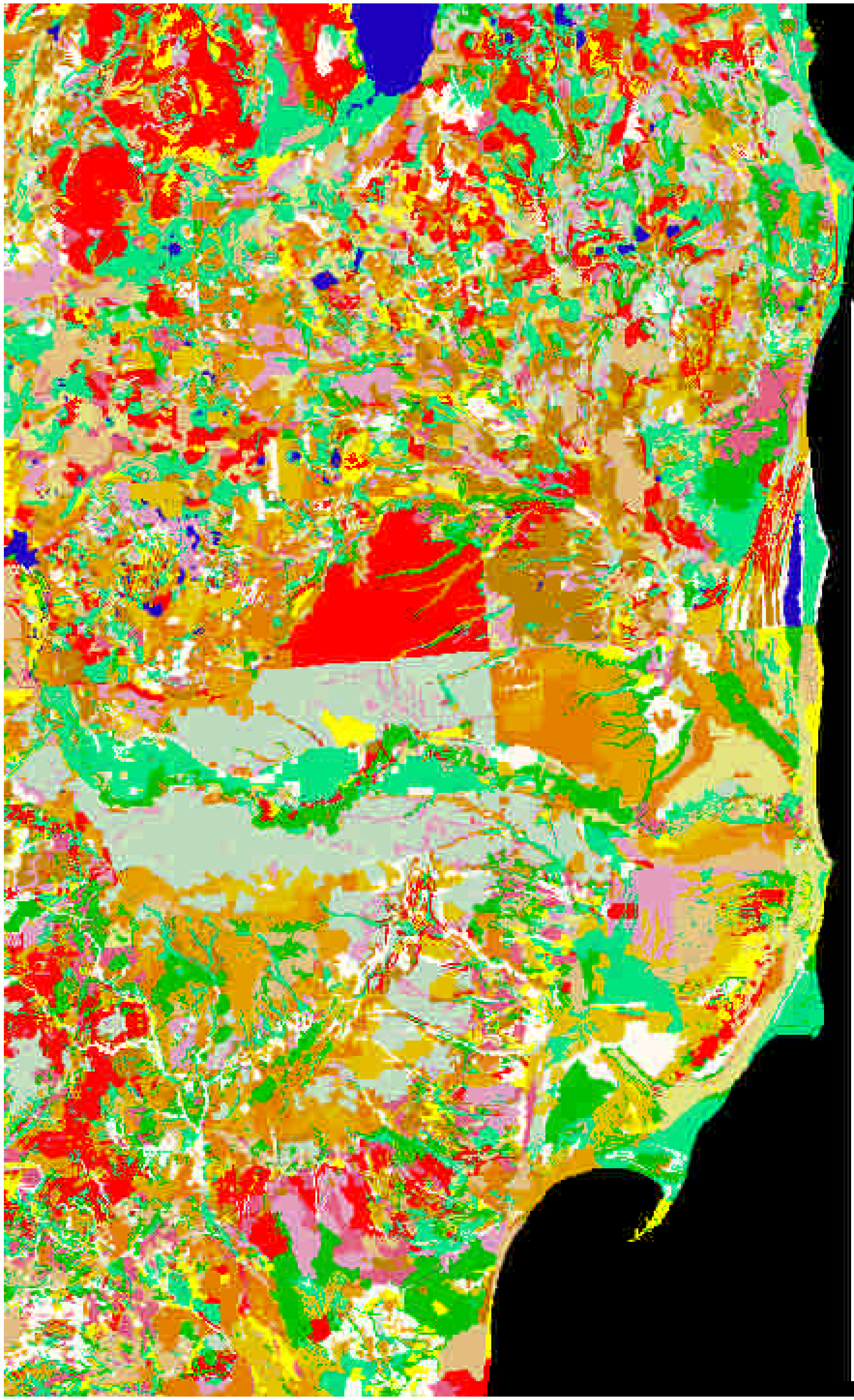
- landform and surficial geology maps
- Natural Resource Conservation Service soil surveys
- ecological unit maps (Subsections and Landtype Associations),
- digital elevation models and derived maps
- pre-European settlement vegetation maps,
- current vegetation maps classified from LANDSAT Thematic Mapper satellite imagery
- FIA plot-level data on current forest conditions
- Records from the original land survey by the General Land Office (GLO) which began in 1826 in Michigan, 1832 in Wisconsin, and 1847 in Minnesota)

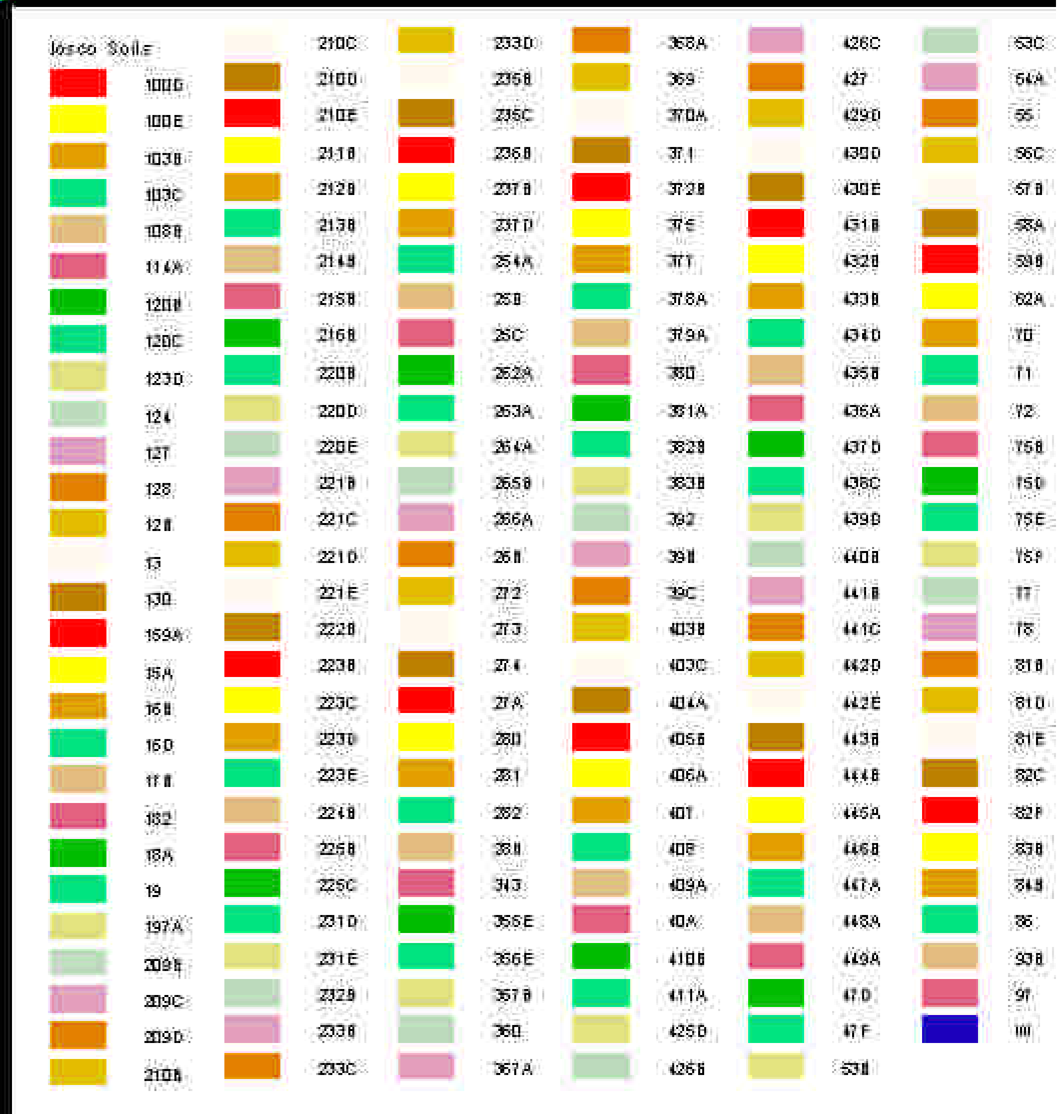

Historical Vegetation
Maple, Beech, and Birch
Northern Hardwood
Northern Hardwood - Hemlock
Hardwood/conifer
Aspen and Birch
Oak
Hemlock
White pine, beech, red maple
Hemlock, white pine
White pine
Red pine
Red pine, white pine
Red pine, jack pine
Jack pine
Barrens
Herbaceous openland
Hemlock, cedar
Cedar
Lowland conifer
Nonforested wetland
Lowland hardwood
Nonforested
Open Water

Mapping tools - Hillshade of DEM and LTA Boundaries

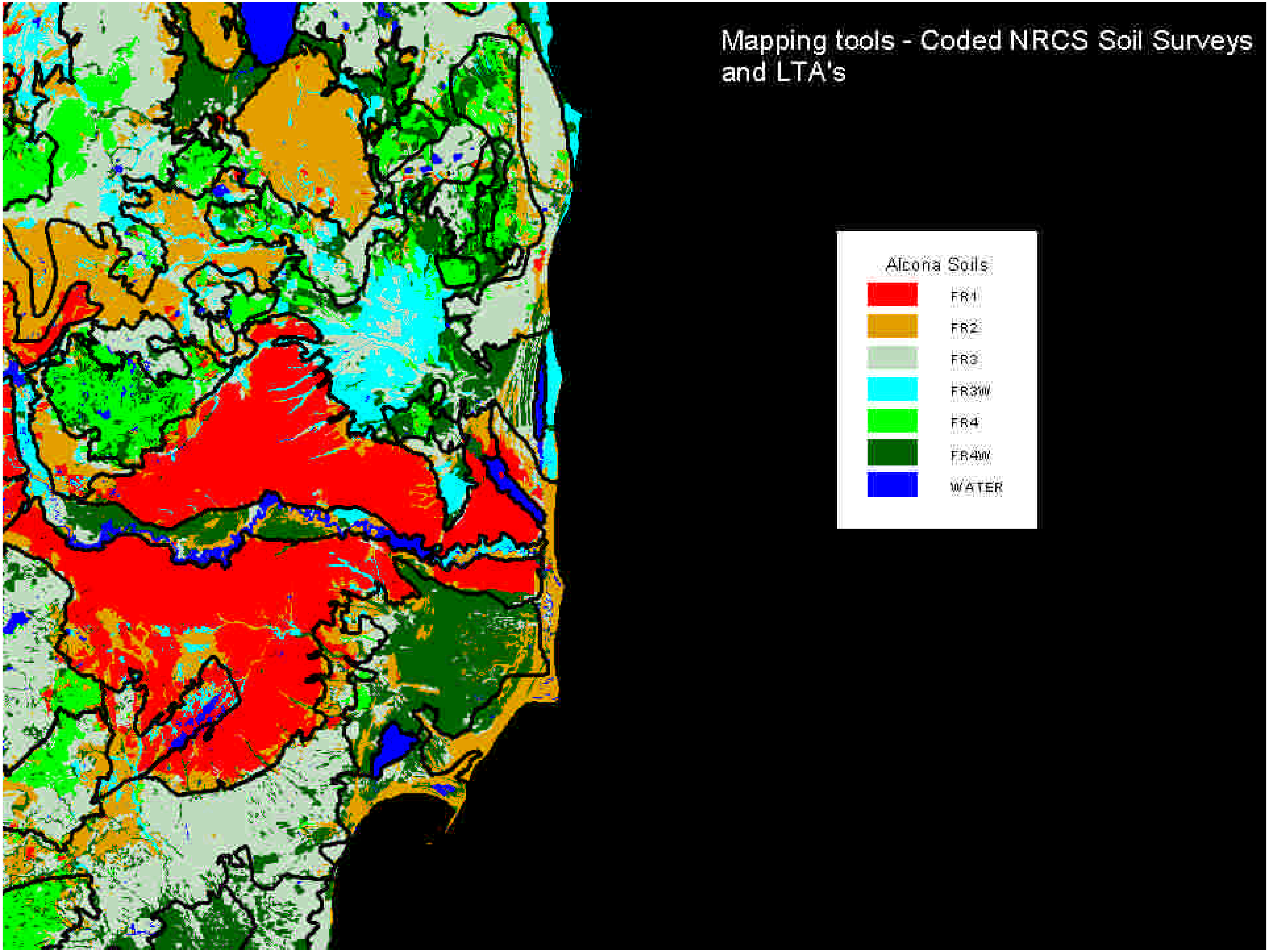


# Mapping tools - NRCS Soil Surveys

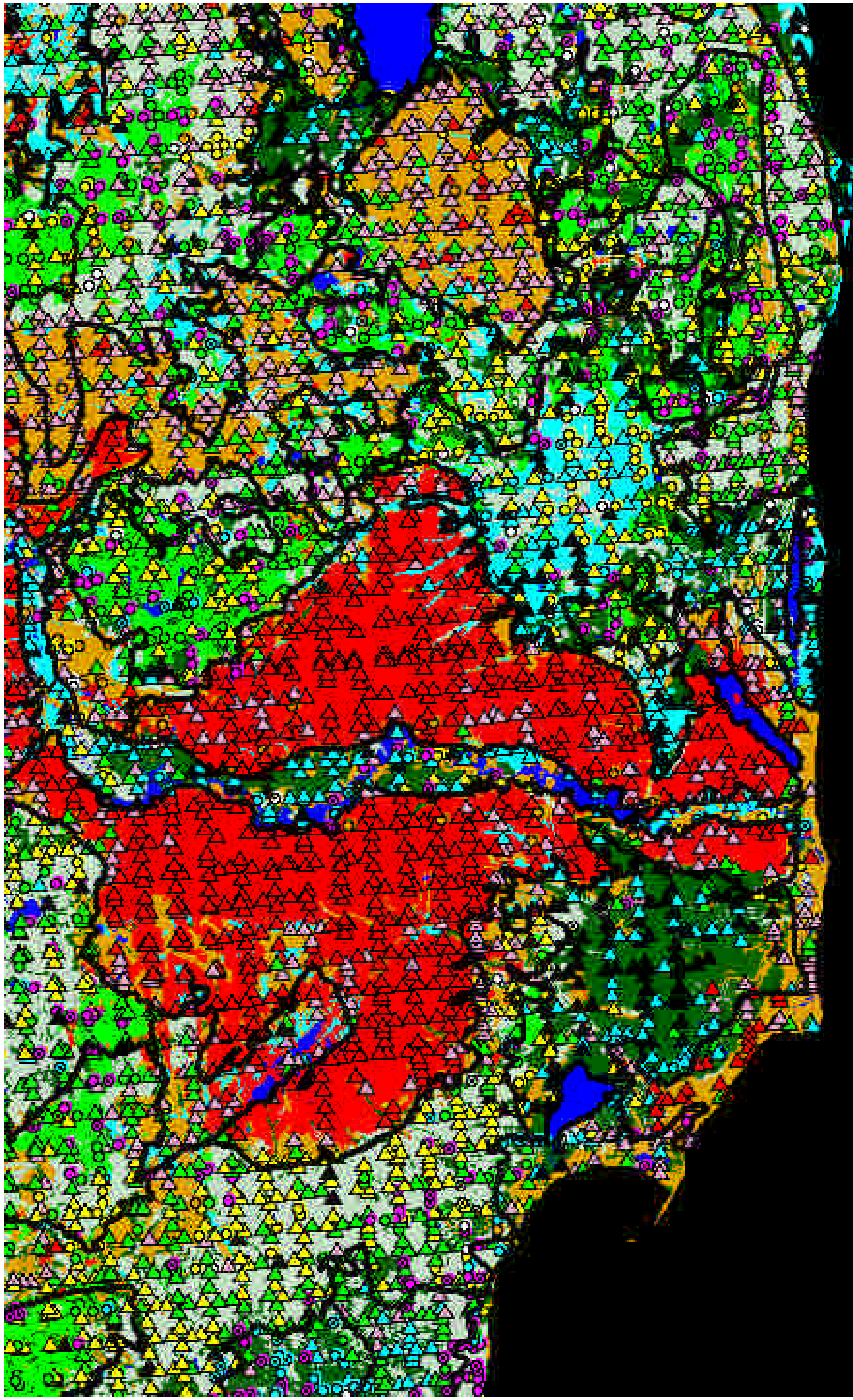




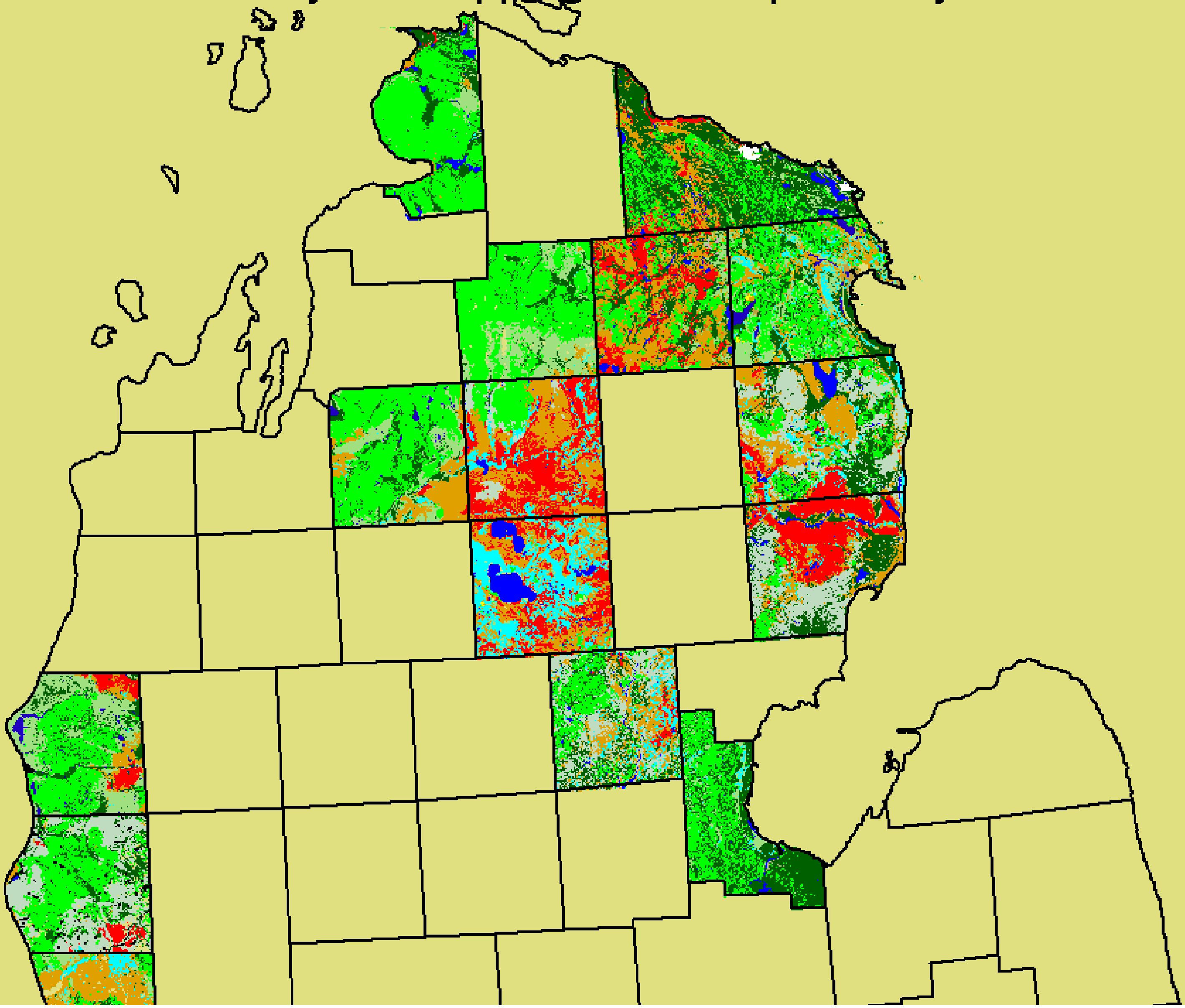
# Mapping tools - Coded NRCS Soil Surveys and LTA's



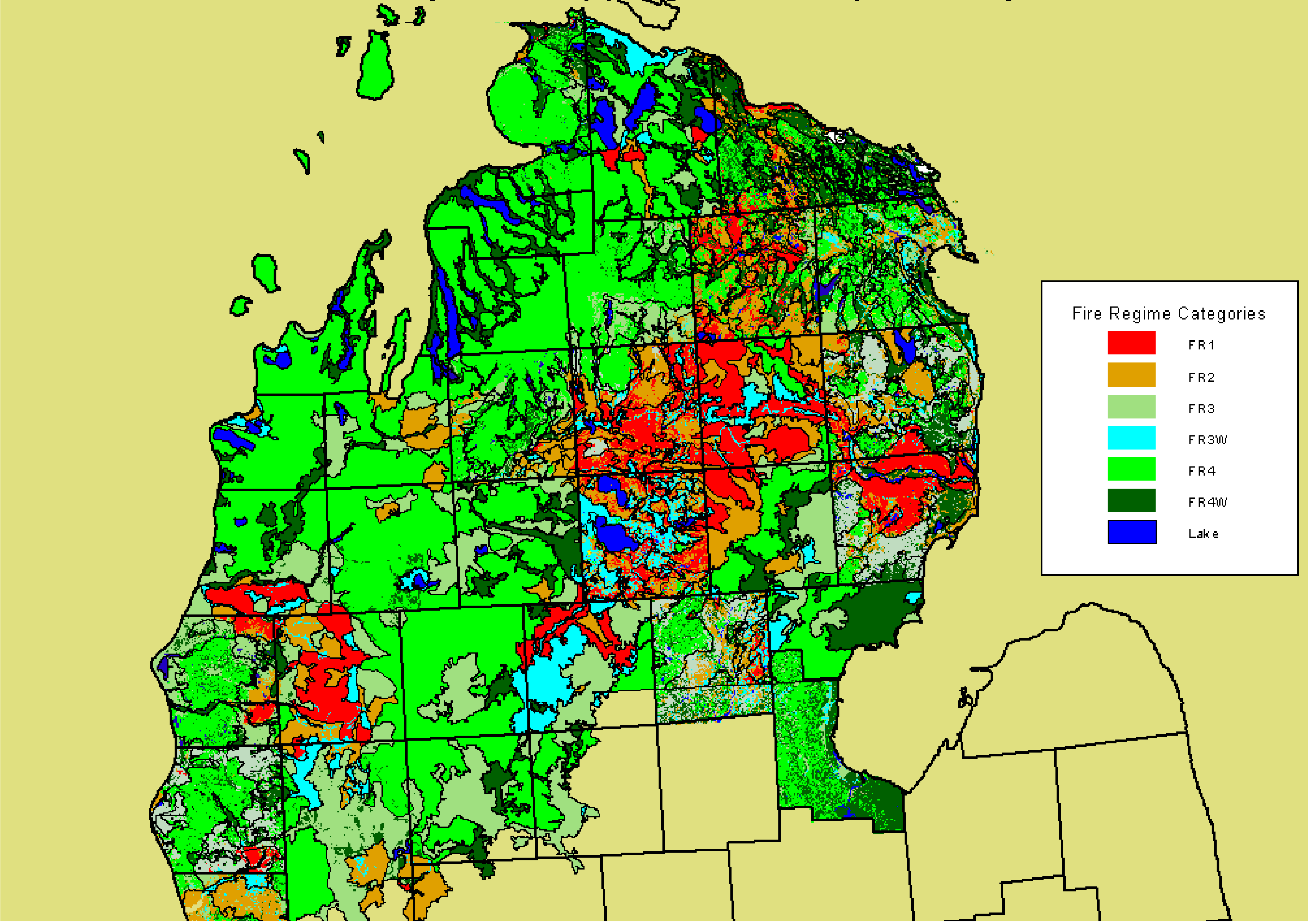
# Mapping tools - Coded NRCS Soil Surveys, LTA's, and GLO Line Trees

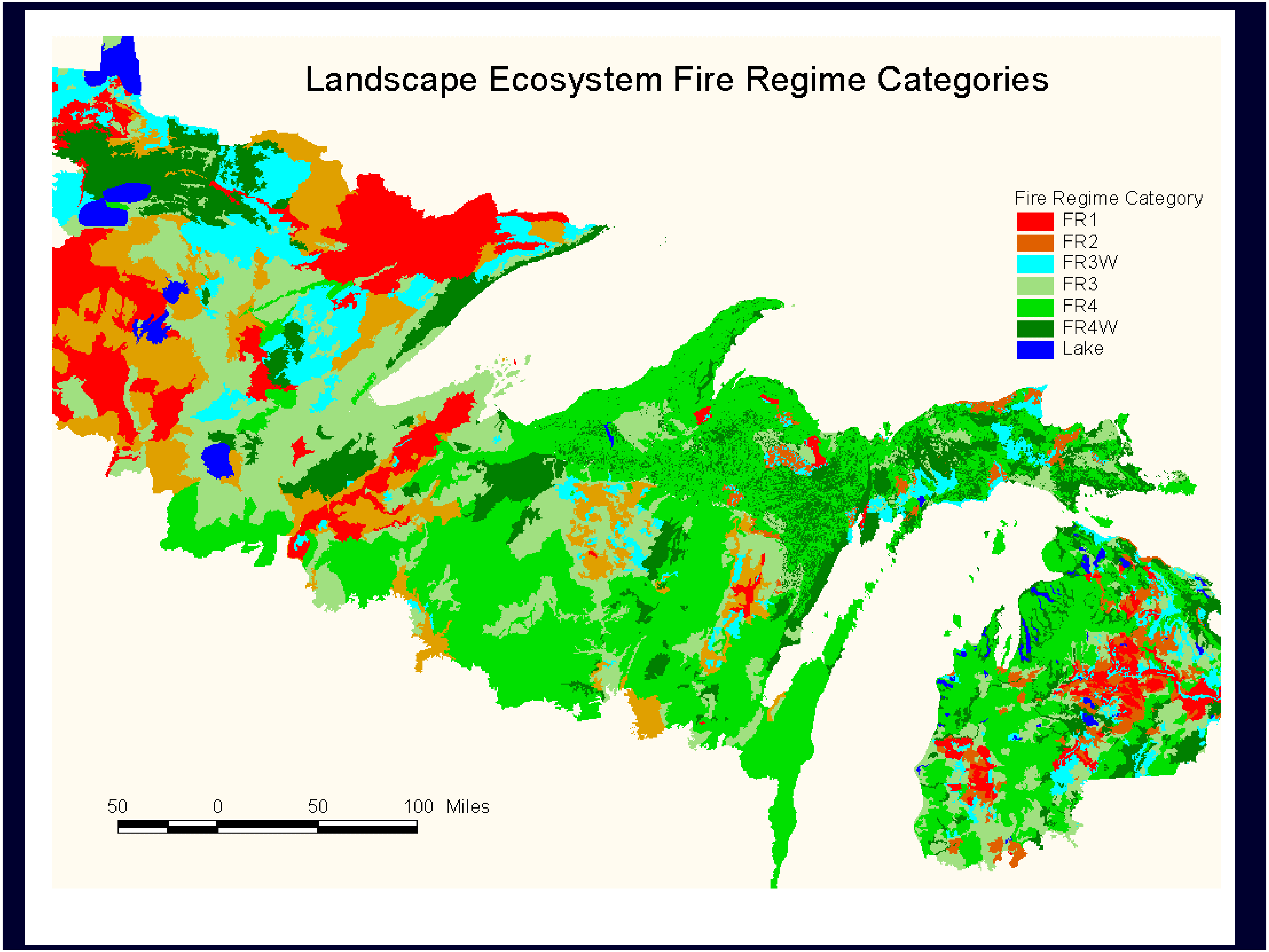


Use of Natural Resource Conservation Service Soil Surveys in Mapping Landscape Ecosystems



# Use of Natural Resource Conservation Service Soil Surveys in Mapping Landscape Ecosystems




Landscape Ecosystem Fire Regime Categories
Fire Regime Category
FR1
FR2
FR3W
FR3
FR4
FR4W
Lake
50 0 50 100 Miles

# Methods for Estimating Historical and Modern Fire Rotations

Use landscape ecosystem category maps as spatial analysis units

Map historical fires by interpolating fire points recorded by the General Land Office using spatial statistics (kriging).

Determine historical fire rotations by calculating the area burned for each fire rotation category and dividing this area by fifteen to estimate area burned per annum.

Determine modern fire rotations by using 1985-2000 data on fire location and size obtained from federal and state agencies.

## Estimating Historical Disturbance Regimes
## Observations of Pre-Suppression Fire Locations

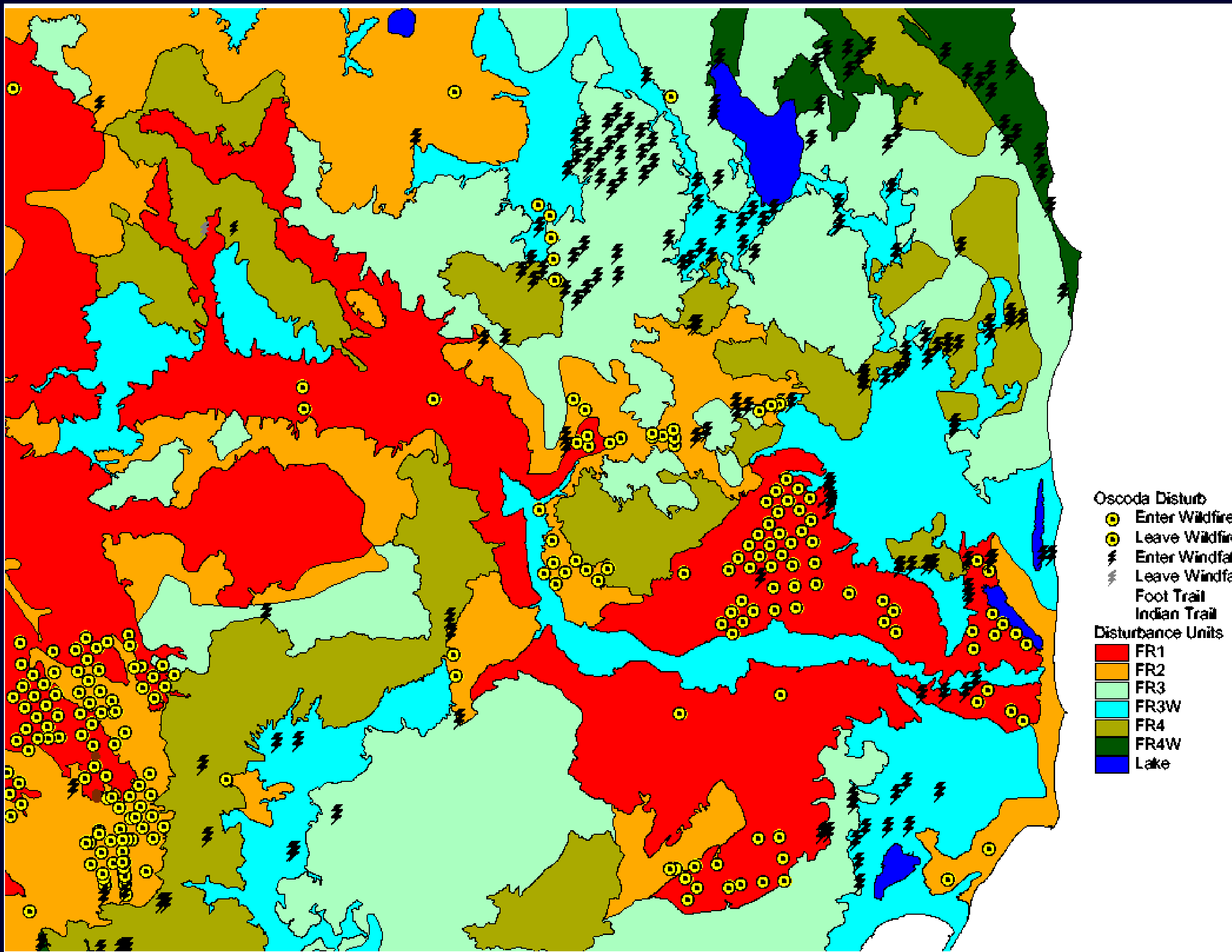
The original land survey by the General Land Office (GLO) is the earliest systematically recorded information on forest conditions in the Lake States.

The GLO surveys began in 1826 in Michigan, 1832 in Wisconsin, and 1847 in Minnesota.

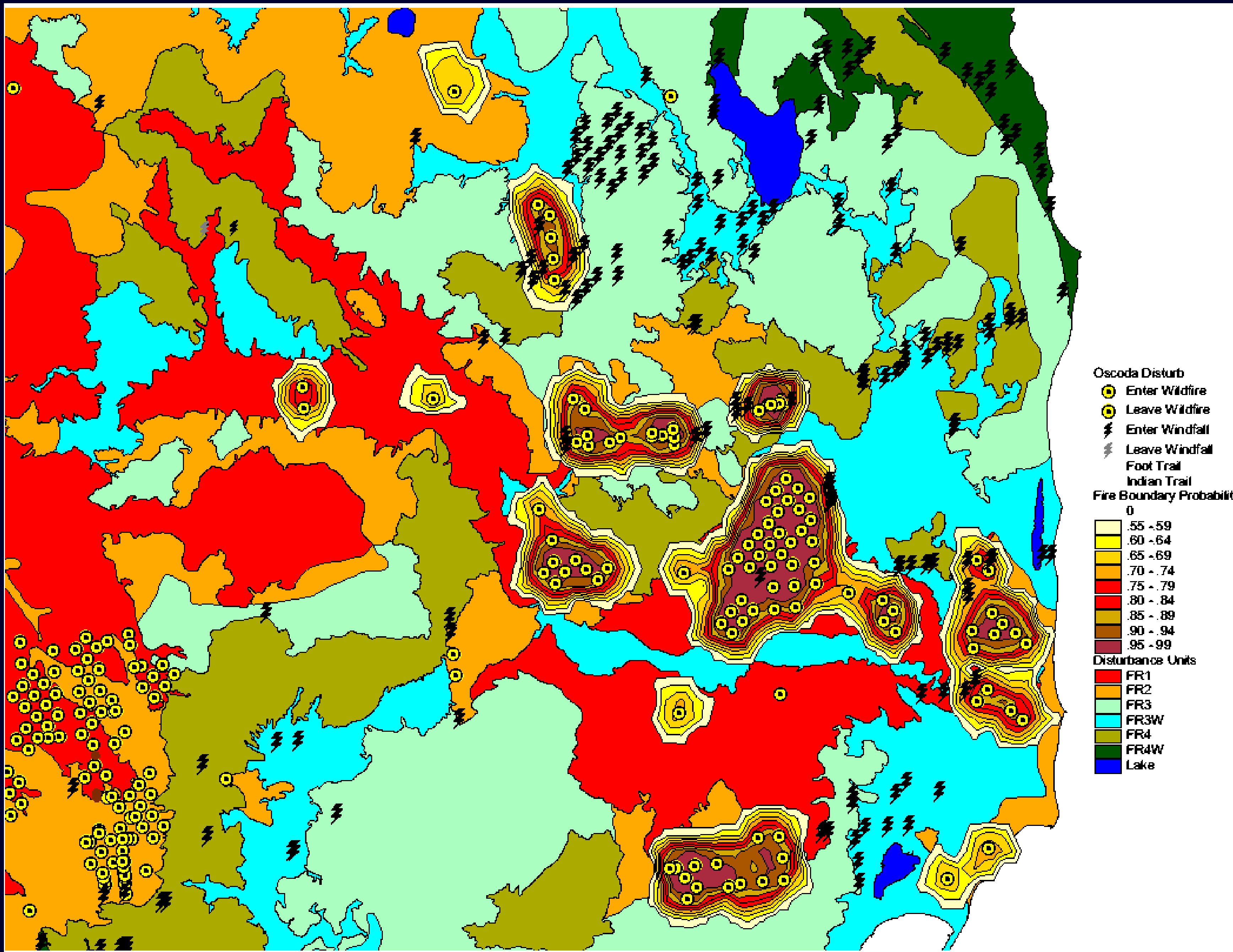
GLO surveyors noted tree species and their diameters at township and section corners and quarter-corners, and along section lines.

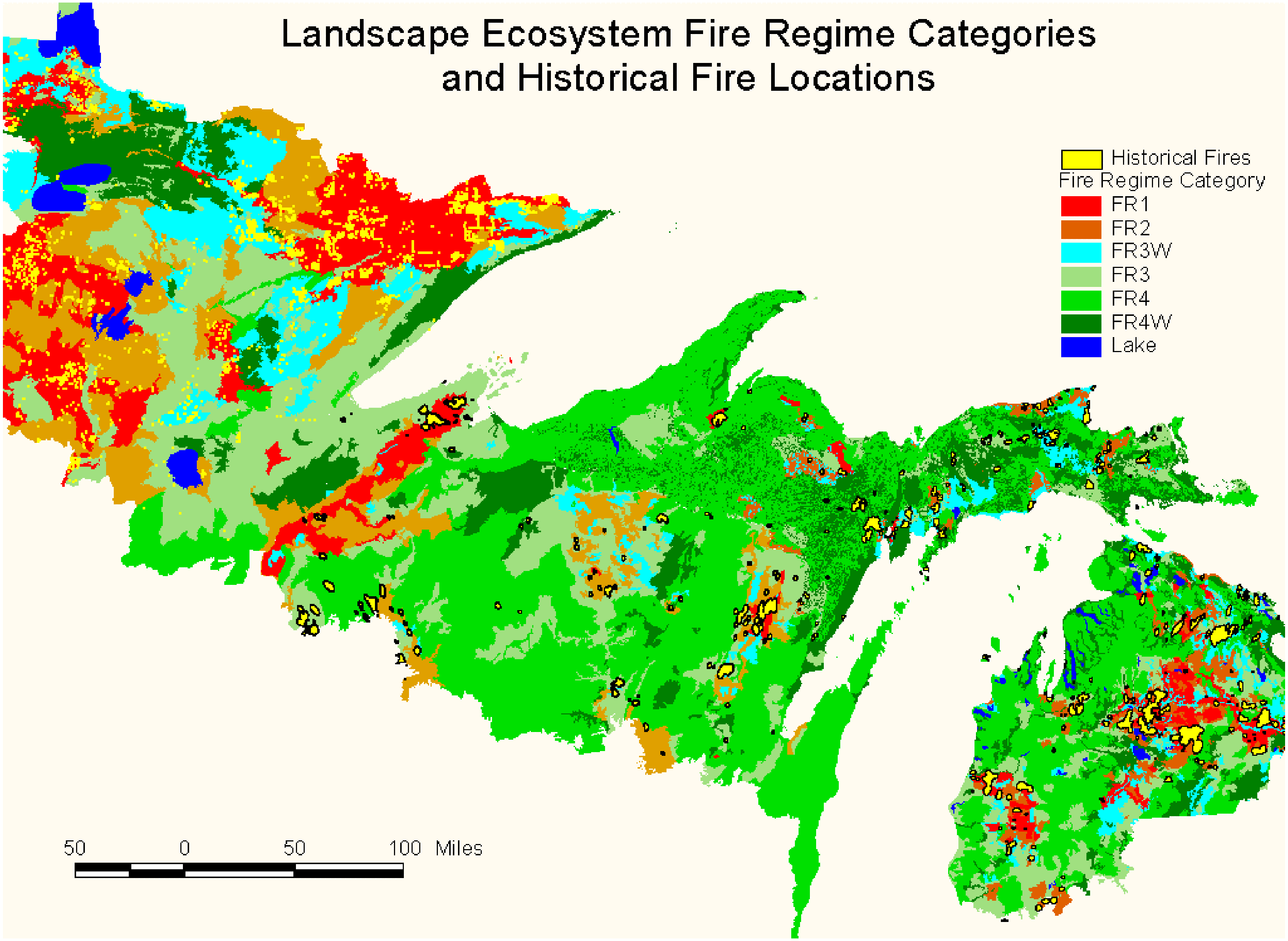
Locations of recently burned areas and windthrows were also recorded.

## Historical Fire and Wind Locations – Oscoda, Alcona Co, MI (an example)

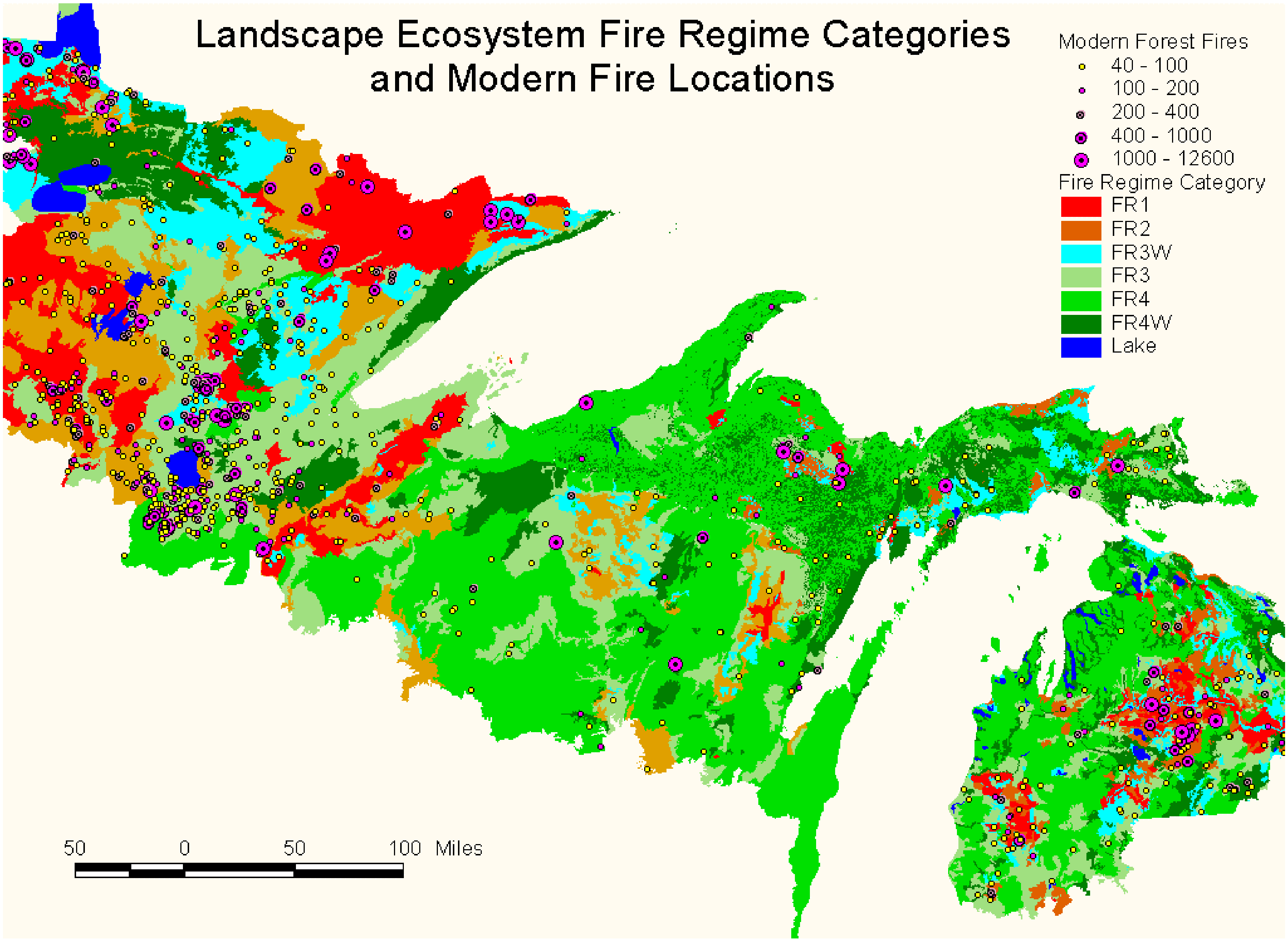


# Interpolation of Fire Points into Fire Boundaries – Probability Kriging





Landscape Ecosystem Fire Regime Categories
and Historical Fire Locations
Historical Fires
Fire Regime Category
FR1
FR2
FR3W
FR3
FR4
FR4W
Lake
50 0 50 100 Miles

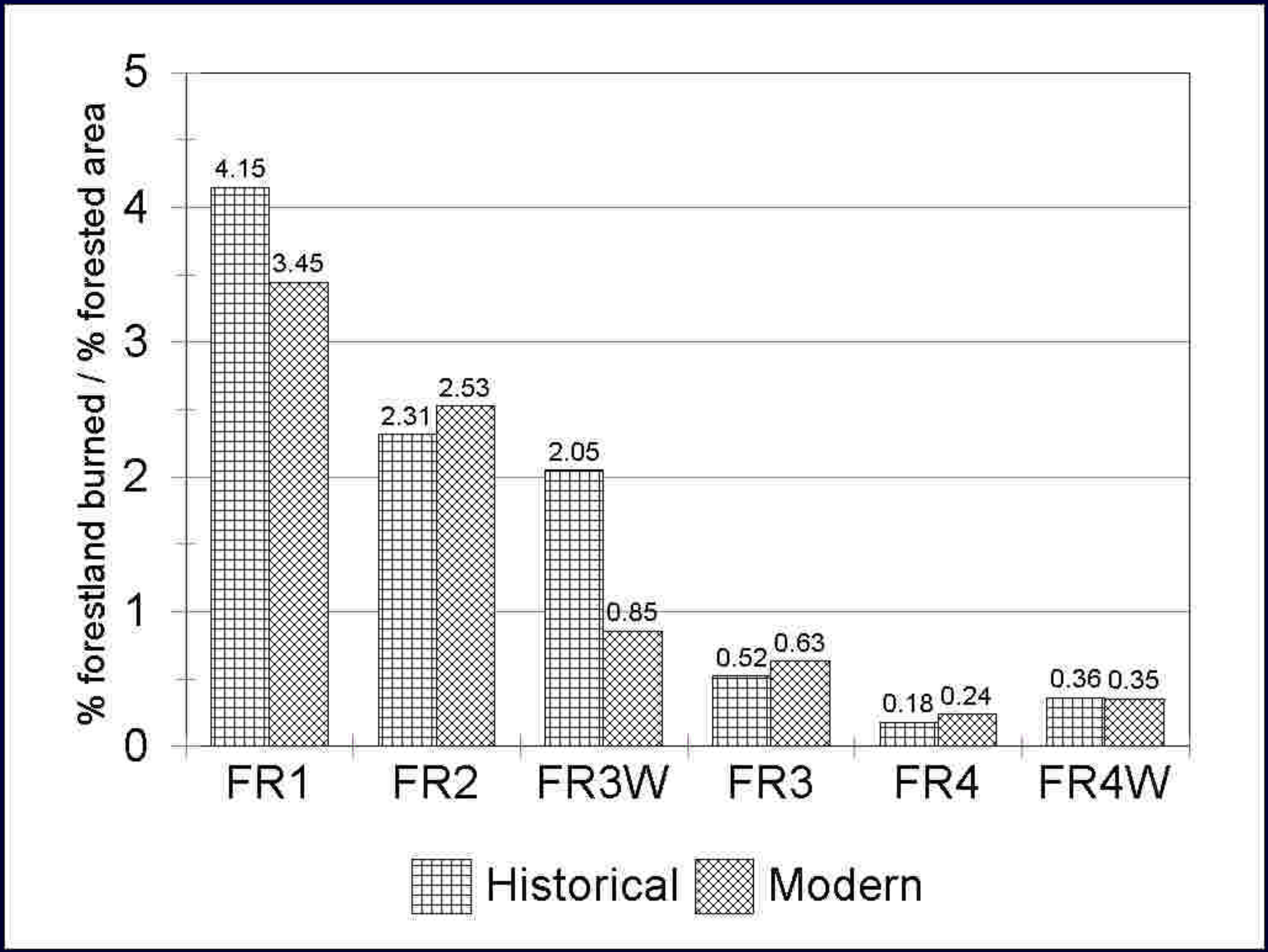

Landscape Ecosystem Fire Regime Categories
and Modern Fire Locations
Modern Forest Fires
40 - 100
100 - 200
200 - 400
400 - 1000
1000 - 12600
Fire Regime Category
FR1
FR2
FR3W
FR3
FR4
FR4W
Lake
50
0
50
100 Miles

# Comparison of Modern and Historical Forest Fire Rotations In Northern Lower Michigan

| Historic Fires | Northern Lower Michigan LTA Grouping | Unit size | Acres burned | % burn/yr | Rotation |
|---|---|---|---|---|---|
| FR1 | Xeric LTA's dominated by jack pine and barrens | 836,192 | 211,075 | 1.683 | 59 |
| FR2 | Less xeric LTA's dominated by white-red pine | 1,029,138 | 144,850 | 0.938 | 107 |
| FR3W | Wetland LTA's adjacent to fire-prone LTA's | 494,638 | 61,617 | 0.830 | 120 |
| FR3 | Dry-mesic LTA's dominated by hemlock-white pine | 1,652,410 | 52,396 | 0.211 | 473 |
| FR4 | Mesic LTA's dominated by northern hardwoods | 3,771,745 | 40,862 | 0.072 | 1,385 |
| FR4W | Wetland LTA's adjacent to mesic hardwood LTA's | 958,232 | 21,012 | 0.146 | 684 |
| Total | Study Area Total | 8,742,355 | 531,812 | 0.406 | 247 |
| | 15 year recognition window | | | | |
| | | | | | |
| Modern Fires | Northern Lower Michigan LTA Grouping | Unit size | Acres burned | % burn/yr | Rotation |
| FR1 | Xeric LTA's dominated by jack pine and barrens | 902,052 | 15,552 | 0.115 | 870 |
| FR2 | Less xeric LTA's dominated by white-red pine | 1,066,009 | 13,766 | 0.086 | 1,162 |
| FR3W | Wetland LTA's adjacent to fire-prone LTA's | 845,278 | 1,763 | 0.014 | 7,192 |
| FR3 | Dry-mesic LTA's dominated by hemlock-white pine | 2,052,353 | 7,219 | 0.023 | 4,264 |
| FR4 | Mesic LTA's dominated by northern hardwoods | 4,340,305 | 3,402 | 0.005 | 19,137 |
| FR4W | Wetland LTA's adjacent to mesic hardwood LTA's | 1,325,801 | 2,103 | 0.011 | 9,456 |
| Total | Study Area Total | 10,531,798 | 43,805 | 0.028 | 3,606 |
| | 15 year recognition window | | | | |

An indication of similarities between historical and modern forest fire rotations is the relative proportion of the percent of total area burned within each fire rotation category to the percent of the study area occupied by each category.

Areas that formerly burned tend to still burn despite aggressive fire suppression activity and effects of wholesale conversion of conifer forests rendered by turn-of-the-century logging.



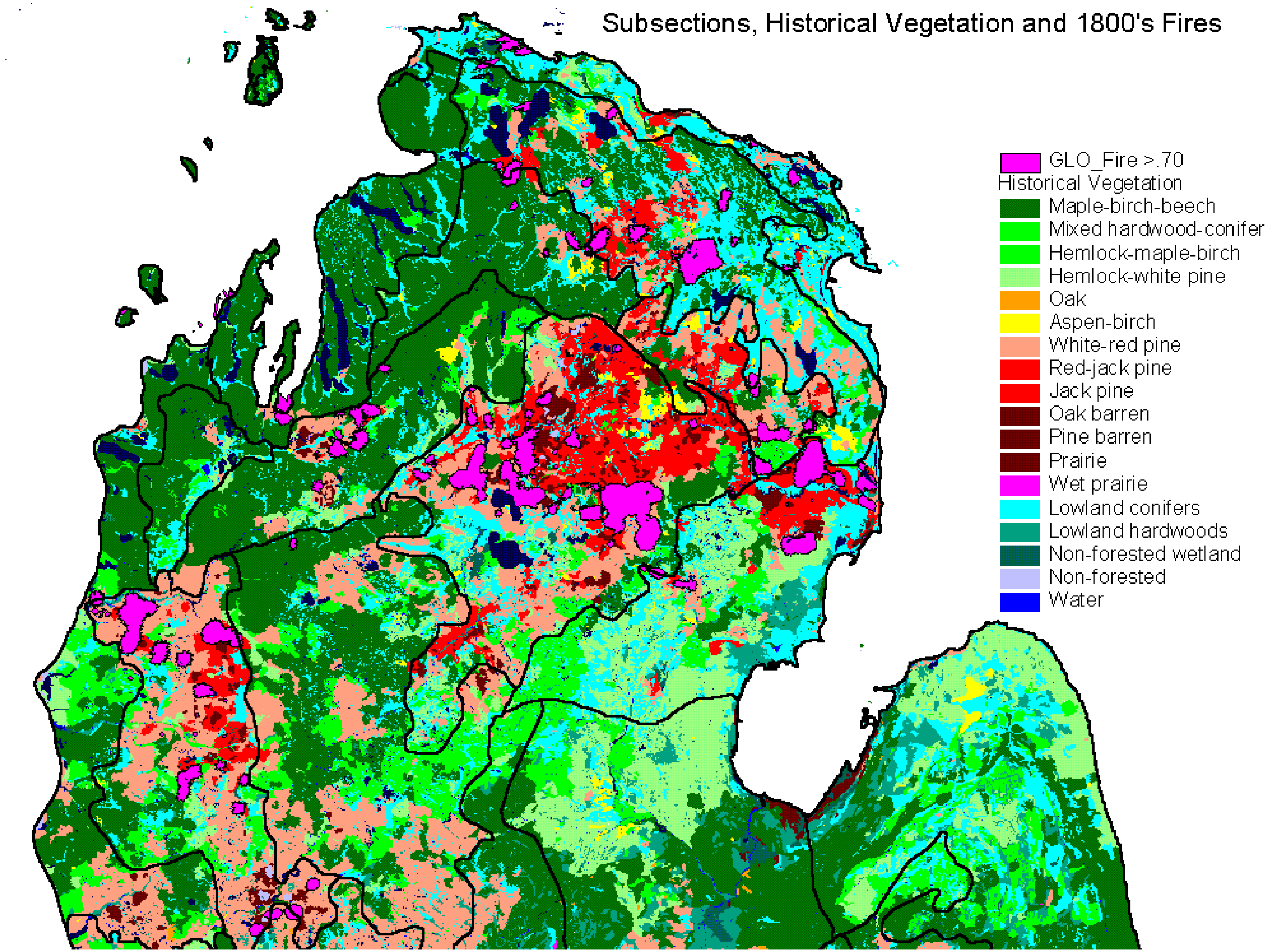
Fire rotations of landscape ecosystem category are similar across states, are supported by the literature, and provide spatially explicit information useful for fine-scale condition class mapping, resource planning and management, and fire risk assessment.

| Historic Fires | LTA Grouping | NLM Rotation | UP Rotation | WI Rotation |
|---|---|---|---|---|
| FR1 | Xeric LTA's dominated by jack pine and barrens | 59 | 79 | 45 |
| FR2 | Less xeric LTA's dominated by white-red pine | 107 | 144 | 250 |
| FR3W | Wetland LTA's adjacent to fire-prone LTA's | 120 | 128 | 441 |
| FR3 | Dry-mesic LTA's dominated by hemlock-white pine | 473 | 449 | 449 |
| FR4 | Mesic LTA's dominated by northern hardwoods | 1,385 | 1,551 | 1,802 |
| FR4W | Wetland LTA's adjacent to mesic hardwood LTA's | 684 | 741 | 2,899 |
| Total | Study Area Total | 247 | 574 | 613 |
| | 15 year recognition window | | | |
| | | | | |
| Modern Fires | LTA Grouping | NLM Rotation | UP Rotation | WI Rotation |
| FR1 | Xeric LTA's dominated by jack pine and barrens | 870 | 374 | 4,350 |
| FR2 | Less xeric LTA's dominated by white-red pine | 1,162 | 7,060 | 8,771 |
| FR3W | Wetland LTA's adjacent to fire-prone LTA's | 7,192 | 6,132 | 9,931 |
| FR3 | Dry-mesic LTA's dominated by hemlock-white pine | 4,264 | 2,010 | 10,071 |
| FR4 | Mesic LTA's dominated by northern hardwoods | 19,137 | 17,543 | 21,631 |
| FR4W | Wetland LTA's adjacent to mesic hardwood LTA's | 9,456 | 4,093 | 9,674 |
| Total | Study Area Total | 3,606 | 5,490 | 12,639 |
| | 15 year recognition window | | | |

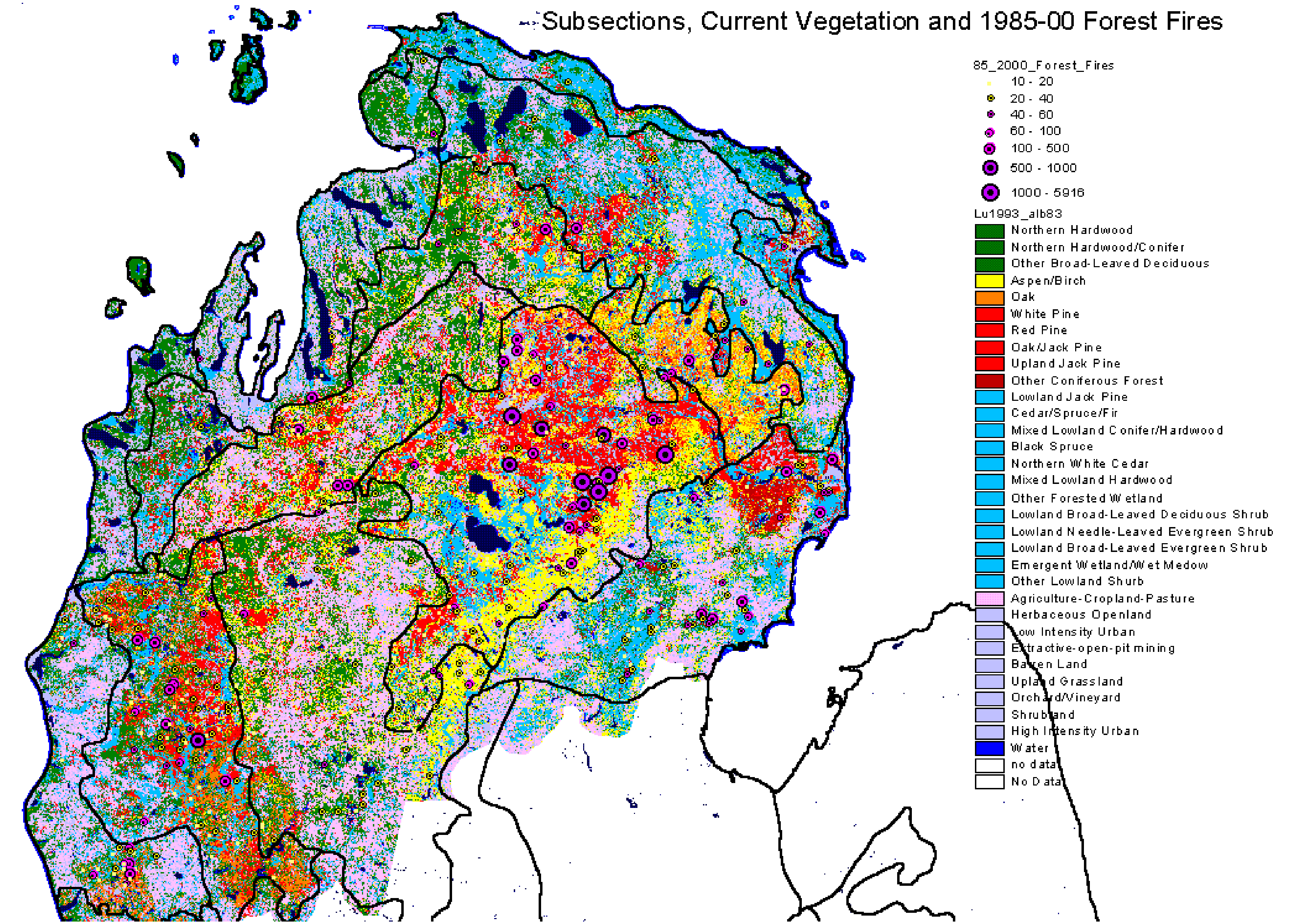
# Results from the literature for select study areas

| Table 2. Historic fire regime categories with associated fire rotation periods for the northern Great Lakes Region | | | | | |
|---|---|---|---|---|---|
| Regime | Community | Fire Rotation | Location | Reference | Notes |
| | Type | Period (Years) | | | |
| | | | | | |
| FR 1 | Jack pine | 80-170 | N. Lower Michigan | Whitney 1986 | Based on GLO record |
| | Jack pine | 130 | Michigan UP (Luce District) | Zhang et al. 1999 | Based on GLO record |
| | Jack pine/black spruce | 50 | N. Minnesota (BWCA) | Heinselman 1981 | Revised estimate bas |
| | Jack pine/black spruce | 100 | Quebec | Chandler et al. 1983 | Source unknown (fro |
| | Jack pine/black spruce | 60 | Ontario | Chandler et al. 1983 | Source unknown (fro |
| | Aspen/birch/fir | 80 | N. Minnesota (BWCA) | Heinselman 1981 | Revised estimate bas |
| | | | | | |
| FR 2-FR 3 | Red/jack//white pine | 130-260 | N. Lower Michigan | Whitney 1986 | Based on GLO record |
| | Red/jack/white pine | 160 | Michigan UP (Luce District) | Zhang et al. 1999 | Based on GLO record |
| | Pine/oak | 170-350 | N. Lower Michigan | Whitney 1986 | Based on GLO record |
| | Red pine/white pine | 180 | N. Minnesota (BWCA) | Heinselman 1981 | Revised estimate bas |
| | Red pine/white pine | 150 | N. Minnesota (Itasca) | Frissel 1973 | |
| | Red pine/white pine | 320 | Michigan UP (Luce District) | Zhang et al. 1999 | Based on GLO record |
| | Aspen/birch | 210 | Michigan UP (Luce District) | Zhang et al. 1999 | Based on GLO record |
| | | | | | |
| FR3W | Tamarack | 190 | Michigan UP (Luce District) | Zhang et al. 1999 | Based on GLO record |
| | Black spruce peatland | 150 | N. Minnesota (Lake Agassiz) | Heinselman 1981 | Estimated |
| | Black spruce | 100 | Ontario | Chandler et al. 1983 | Source unknown (fro |
| | | | | | |
| FR 4 | Sugar maple/hemlock | 900 | Michigan UP (Porcupine Mtns) | Frelich & Lorimer 1991 | Surface & stand repla |
| | Sugar maple/hemlock | 550 | Michigan UP (Huron Mtns) | Frelich & Lorimer 1991 | Surface & stand repla |
| | Northern hardwoods/ pine/hemlock | 1400-2800 | N. Lower Michigan | Whitney 1986 | Based on GLO record |
| | Northern hardwoods | 2600 | Michigan UP (Luce District) | Zhang et al. 1999 | Based on GLO record |
| | Northern hardwoods | 1000+ | New Hampshire | Bormann & Likens 1979 | Estimated |
| | Sugar maple/hemlock | 1700 | Michigan UP (Sylvania Tract) | Frelich & Lorimer 1991 | Based on surface & s |
| FR4W | Swamp conifers | 3000-6000 | N. Lower Michigan | Whitney 1986 | Based on GLO record |
| | White cedar | 1700 | Michigan UP (Luce District) | Zhang et al. 1999 | Based on GLO record |
| | Lowland hardwood/conifer | 1100 | Michigan UP (Luce District) | Zhang et al. 1999 | Based on GLO record |
| | Mixed lowland conifer/hardwoods | 580 | Michigan UP (Luce District) | Zhang et al. 1999 | Based on GLO record |
| | Black spruce | 890 | Michigan UP (Luce District) | Zhang et al. 1999 | Based on GLO record |

# Effect of Scale and Choice of Spatial Analysis Units on Measures of Fire Regimes


Subsections, Historical Vegetation and 1800's Fires
GLO_Fire >.70
Historical Vegetation
Maple-birch-beech
Mixed hardwood-conifer
Hemlock-maple-birch
Hemlock-white pine
Oak
Aspen-birch
White-red pine
Red-jack pine
Jack pine
Oak barren
Pine barren
Prairie
Wet prairie
Lowland conifers
Lowland hardwoods
Non-forested wetland
Non-forested
Water

# Subsections, Current Vegetation and 1985-00 Forest Fires



| | Total | Historic Fire | Modern Fire | | Historic Fire | Modern Fire |
|---|---|---|---|---|---|---|
| **Subsection** | **Acreage** | **Acreage** | **Acreage** | | **Rotation** | **Rotation** |
| 212Ha | 873,340 | 2,584 | 1,516 | | 5,069 | 8,643 |
| 212Hb | 1,041,381 | 88,120 | 4,539 | | 177 | 3,441 |
| 212Hc | 1,711,575 | 2,117 | 1,764 | | 12,127 | 14,553 |
| 212Hd | 250,234 | 0 | 232 | | infinity | 16,158 |
| 212He | 822,100 | 26,662 | 1,623 | | 463 | 7,597 |
| 212Hf | 851,125 | 5,058 | 732 | | 2,524 | 17,433 |
| 212Hg | 1,705,941 | 161,899 | 25,607 | | 158 | 999 |
| 212Hh | 1,088,199 | 57,232 | 4,022 | | 285 | 4,058 |
| 212Hi | 519,919 | 10,945 | 1,007 | | 713 | 7,742 |
| 212Hj | 1,228,741 | 65,443 | 1,629 | | 282 | 11,299 |
| 212Hk | 369,714 | 19,274 | 1,137 | | 288 | 4,900 |
| 212Hl | 460,579 | 16,537 | 275 | | 418 | 25,155 |
| **Total** | **10,922,848** | **455,871** | **44,084** | | **359** | **3,717** |

* 15 year recognition window assumed for GLO observations

# Characterizing Modern Fire Regimes in Addition to Fire Rotations

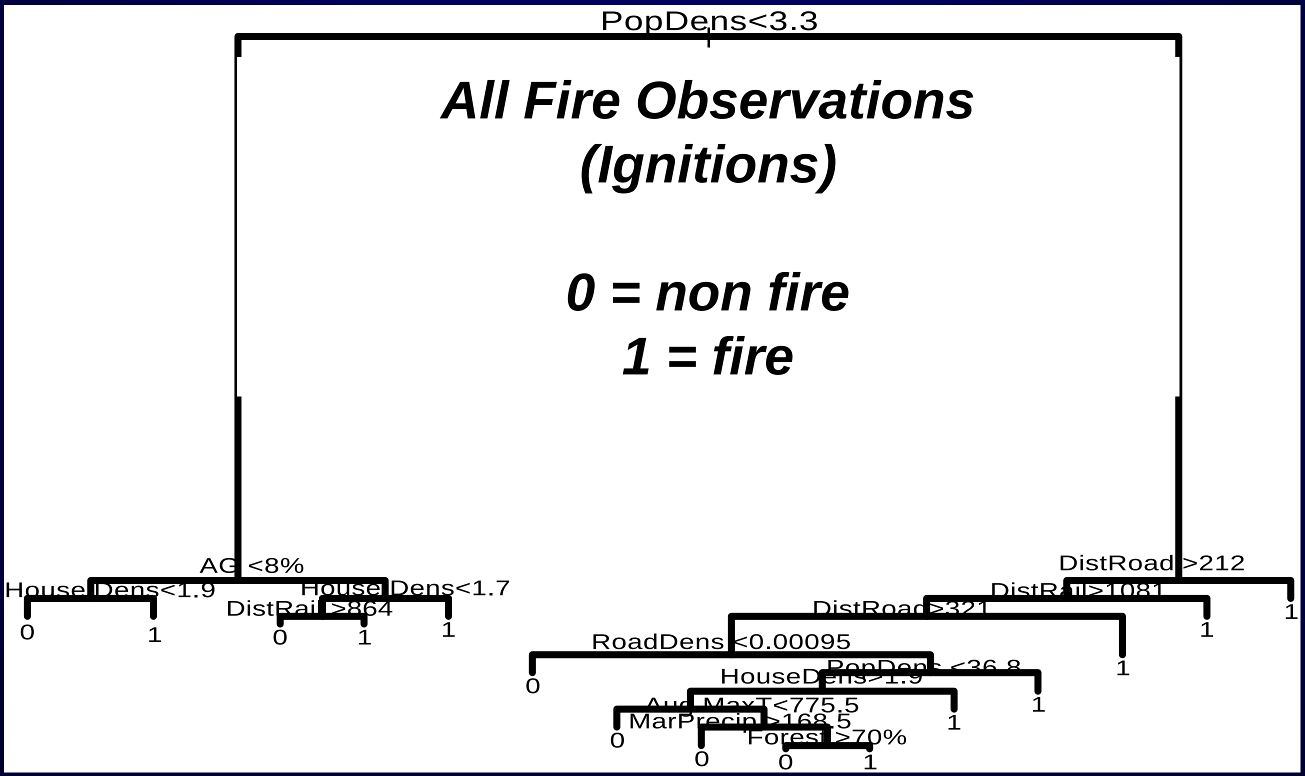
We are assessing relationships among social and ecological factors using classification and regression tree analyses.

We are developing predictive models of fire occurrence using logistic regression.

## Classification Tree Analyses of Modern Fire Regimes

Results suggest that fire ignitions are related primarily to factors associated with human populations.

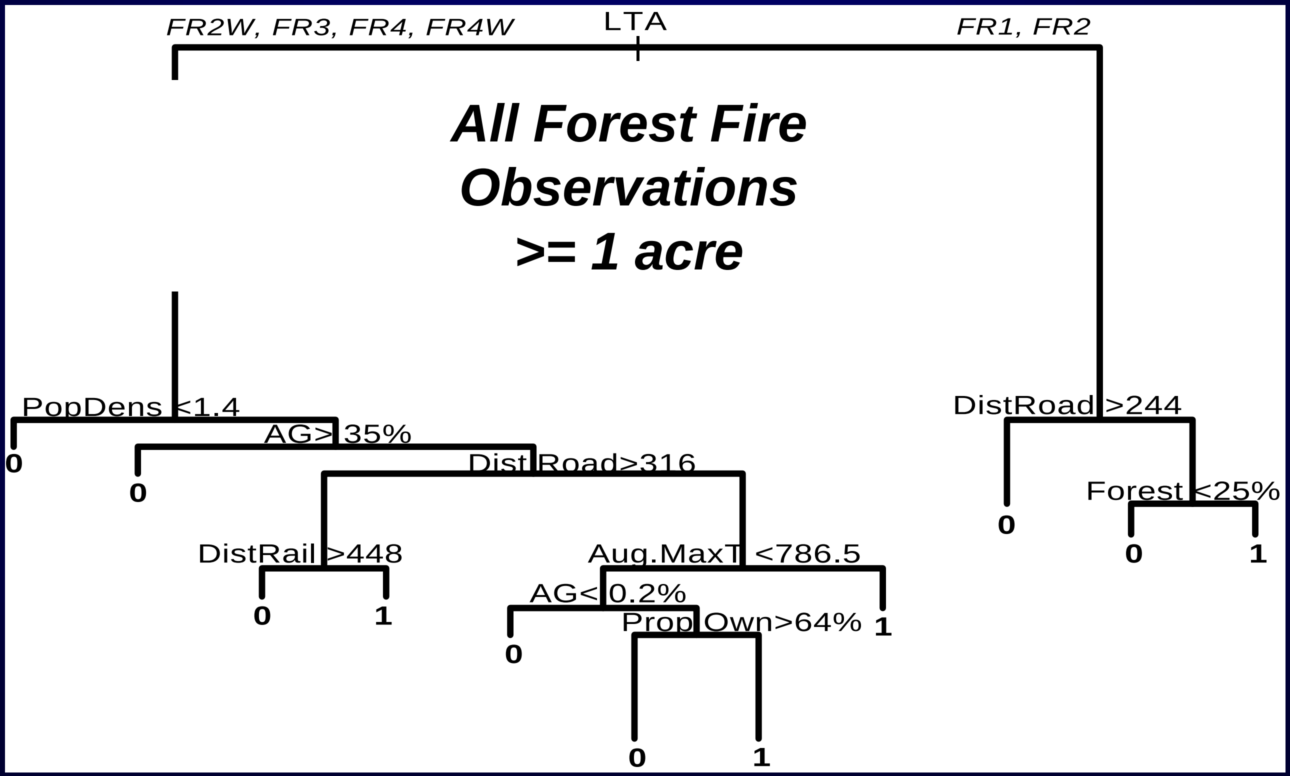
Less important indicators of ignition risk include variables associated with human access, such as distance to nearest road or railroad.



## Classification Tree Analyses of Modern Fire Regimes

However increasing the minimum fire size increases the importance of ecological indicators of fire risk.

Analyses in Wisconsin suggest Landtype Association is the most important indicator of forest fire observations greater than one acre.



# What Is A Logistic Model?

- A regression model.
- Used when the response variable is binary (i.e., has two possible outcomes).
- Used to predict the probability of occurrence of one of the outcomes.

where that probability (P) is calculated as:

$$P = \frac{e^V}{1+e^V}$$

and *V* is a linear combination of explanatory variables (X):

$$V = \mathrm{b}_0 + \mathrm{b}_1 X_1 + \mathrm{b}_2 X_2 \ldots \mathrm{b}_n X_n$$

# What Does Our Tri-State Model Look Like?

$$V = -0.778 + 2.967X_1 - 0.142X_2 - 0.009X_3 + 1.147X_4 + 0.829X_5 + 0.860X_6$$

where

**X1 = road density**
**X2 = minimum temperature**
**X3 = precipitation**
**X4 = population density**
**X5 = jack pine (1 = is jack pine, 0 = is not jack pine)**
**X6 = aspen birch (1 = is aspen birch, 0 = is not aspen birch)**

This equation is then used to calculate the probability of a burn using

$$P = \frac{e^V}{1 + e^V}$$

for each point used in the model (burn or non burn).

# How Useful Is Our Model?

One way to determine this is to calculate

**SENSITIVITY = the percentage of events classified correctly by the model**

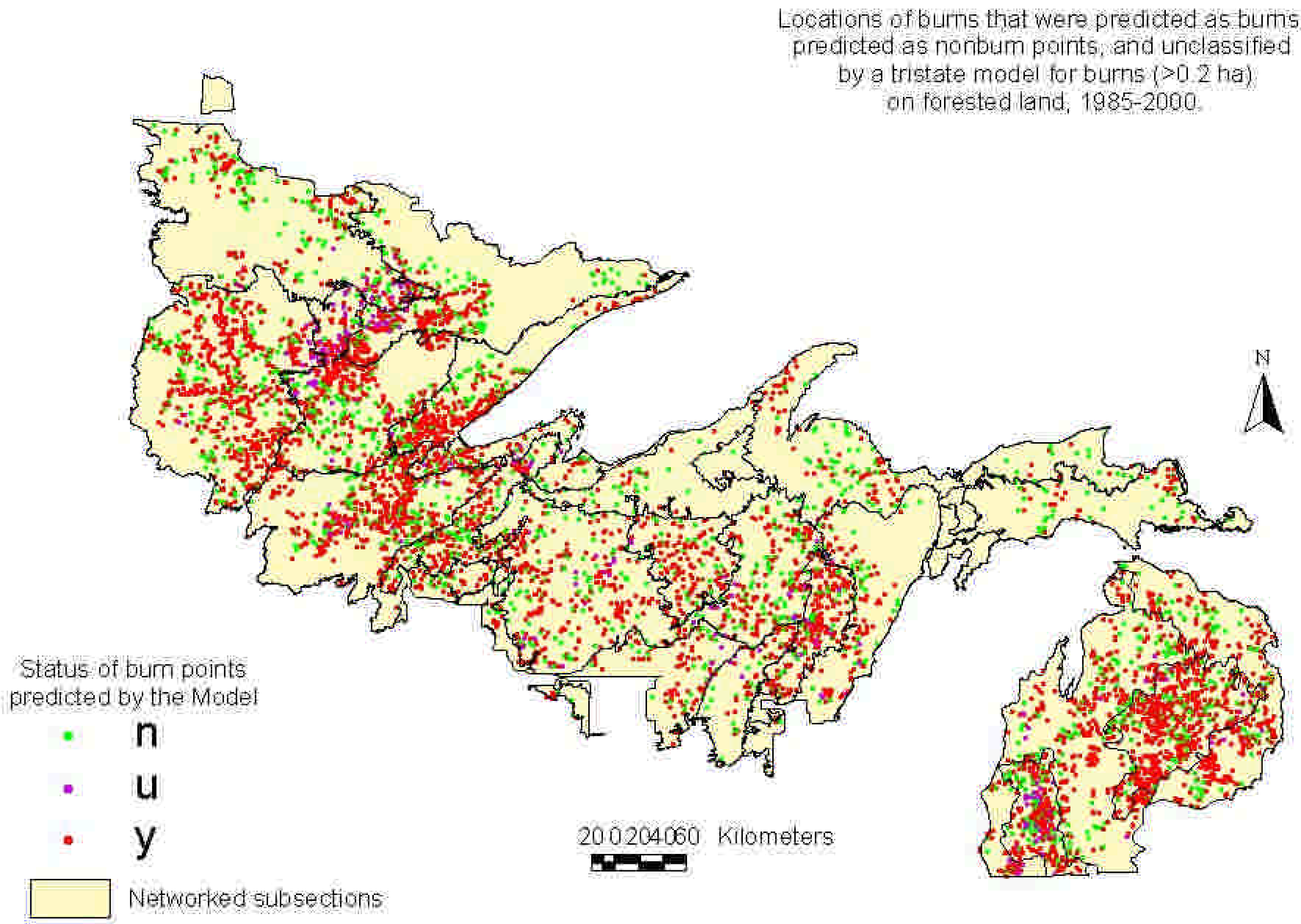
*(i.e., the % of actual fires correctly "classified as fires" by the model)*

Generally, a point is considered "*classified as a fire*" when **P** $^{3}$ **0.5**

To understand sensitivity quantitatively:

| | | Classification | |
|---|---|---|---|
| | | Fire | Non Fire |
| Actual Situation | Fire | A | B |
| | Non Fire | C | D |

Sensitivity = (A/(A+B))*100%


Locations of burns that were predicted as burns,
predicted as nonburn points, and unclassified
by a tristate model for burns (>0.2 ha)
on forested land, 1985-2000.
N
Status of burn points
predicted by the Model
n
u
y
20 0 20 40 60 Kilometers
Networked subsections

## Sensitivity of the initial tri-state logistic model predicting the probability of a burn greater than 1 acre.

| Spatial Unit | N (classified) | Sensitivity |
|---|---|---|
| | | |
| **Tristate Model** | 7958 | 75 |
| | | |
| **State Model** | | |
| MN | 3592 | 75.8 |
| WI | 1897 | 73.4 |
| MI | 2469 | 75.2 |
| | | |
| **Networked subsection** | | |
| Hb | 1086 | 81.5 |
| He | 554 | 75.2 |
| Hh | 406 | 76.6 |
| Ja | 180 | 77.2 |
| Jb | 58 | 58 |
| Ka | 260 | 70.8 |
| Kb | 697 | 77.8 |
| La | 469 | 72.7 |
| Lb | 462 | 82.2 |
| Ma | 385 | 59.2 |
| Na | 900 | 78.9 |
| Nb | 687 | 75.4 |
| Qa | 174 | 77.5 |
| Qb | 43 | 43 |
| Ri | 26 | 26 |
| Rk | 77 | 49.4 |
| Sb | 146 | 59.6 |
| Ta | 72 | 72.2 |
| Tb | 164 | 72.5 |
| Tc | 293 | 81.2 |
| Xa | 633 | 68.6 |
| Xb | 183 | 81.4 |
| Za | 3 | 66.7 |

# Summary of Comparison of Modern and Historical Fire Regimes

Fire suppression has extended fire rotations by one to two orders of magnitude.

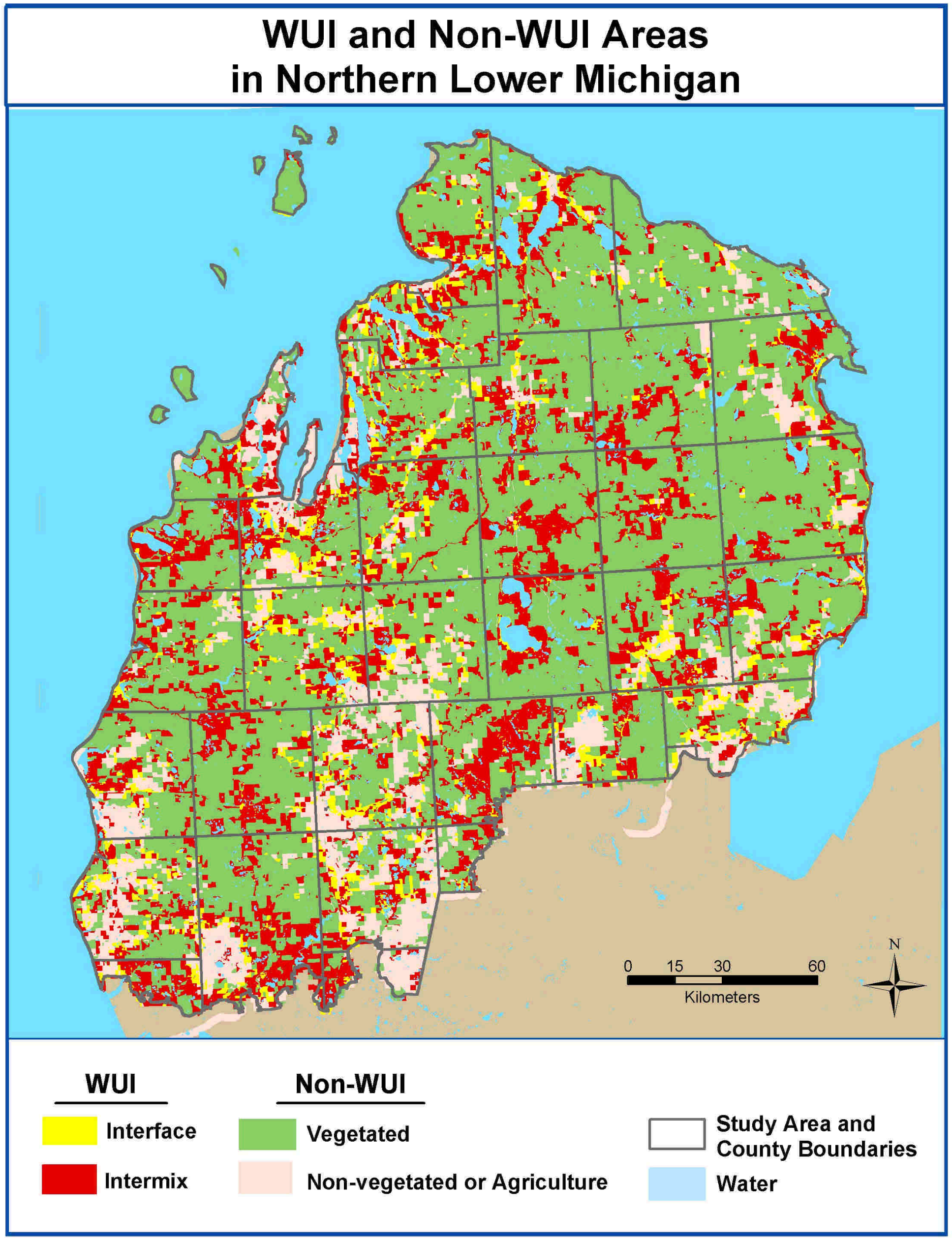
Landtype Associations networked into fire rotation categories exhibited differences in both historical and modern fire regimes.

Historical fire regimes were strongly associated with the physical environment regulating the distribution of vegetation and fire spread.

Modern fire ignitions are almost exclusively associated with human population density and access rather than ecological factors.

Modern forest fires larger than one acre are more strongly associated with ecological factors than social factors.

Collectively, our results indicate that while humans factors dominate the probability of modern fire ignitions, ecological factors constrain the ability of those fires to spread.

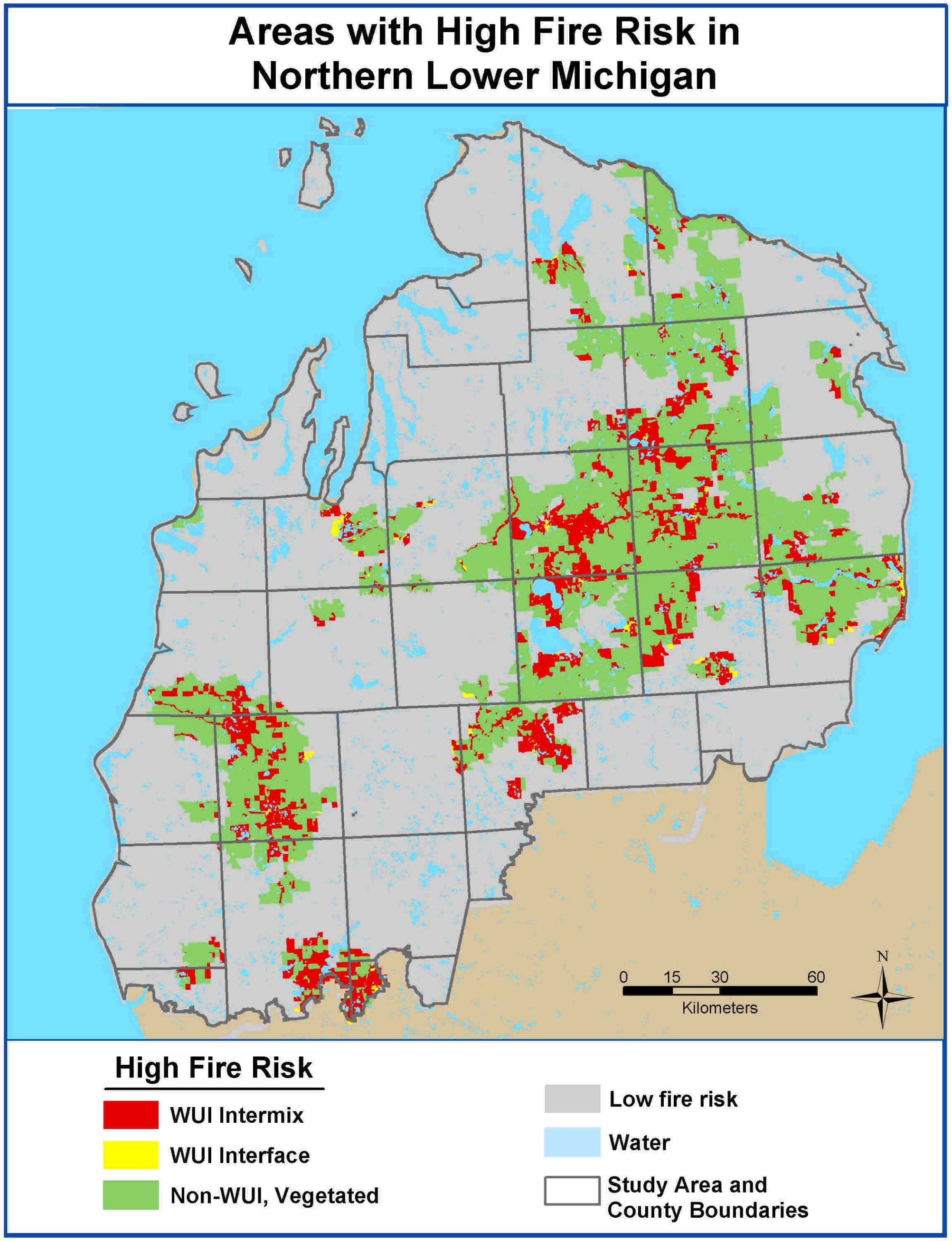



Assessing fire risk includes quantifying the consequences of wildfires on humans as well as resources.

We based our WUI classification on definitions of wildland urban interface and intermix communities that were developed by an interagency team in 2001.

An interface community exists where structures such as homes or business facilities directly abut wildland fuels with a clear line of demarcation between them.

An intermix community exists where structures are scattered throughout a wildland area and wildland fuels are continuous outside of and within the developed area.




Our fire risk assessment combines the location of human development, the arrangement and flammability of fuels, and landscape ecosystem fire rotation categories.